INTEGRATED EDITION OF THE PETROLEUM ENGINEER

the Petroleum Engineer

FOR MANAGEMENT

JANUARY 1960

CONTENTS: 2 AD INDEX: 6

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OUTLOOK

GET READY FOR THE STAR SPANGLED 60's

MORE EFFECTIVE ACIDIZING WITH THE EXCLUSIVE NEW "ACID GUIDE" BEGINS HERE

This is a Dowell field laboratory. From more than 40 such installations strategically located throughout the oil producing areas, Dowell can provide a new method for engineering more effective acid treatments. This new method is called the "Acid Guide."* When the "Acid Guide" is used as a basis for planning a treatment, the Dowell engineer first tests core samples or cuttings for solubility and reaction rate. Using this data, he can determine the optimum injection rate, amount of acid and acid formula. This new, greatly improved method for planning and predicting the results of oil well acidizing treatments is available *only* from Dowell . . . and at no extra cost . . . another example that you get more for your money when you *dial Dowell.* Dowell, Tulsa 1, Oklahoma.

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Services for the oil industry

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If You Sell Oil & Gas Equipment and Services, Read . . .

STAR SPANGLED SIXTIES

. . That's the space age keystone that Ernestine Adams has given her forecast (page A-8) of the oil and gas decade ahead.

Consensus of some of your industry's leaders seems to be that the "centers of activity" will shift. U. S. trend will be toward the Rocky Mountains, into the Gulf, and up to Alaska. Worldwide, watch Libya, French Africa, the Philippines, Spanish Morocco and Australia increase in importance in the near future.

> Rate of growth in crude demand is about 4% per year for the U. S., and about 7-1/2% for the rest of the Free World. Using 1958 as an indicator, European consumption of crude ran about 8 million barrels per day . . . equivalent to 16% of the world's total consumption. Demand for petroleum has increased at an annual rate of almost 13% in Western Europe alone (Belgium up 18%, Austria up 10%, Denmark 12%, West Germany 14%, France 14%). This growth is double the growth rate of our gross national product. By 1962, foreign petroleum demand is expected to equal that of the U. S., and by 1965 to exceed U. S. demand by 15%.

1958 was the first year in which capital expenditures in foreign development exceeded that spent in the U. S. ($5.4 billion abroad vs. $5.3 billion in this country - see table on page A-9 recording '58, '59 plus projected '60).

Be sure to read "1960 Trends . . ." on page A-9 of this issue, . . . some revealing market facts in thumbnail form.

Did you know . . .

. . . domestic demand for the first 9 months of '59 was up 5.5%

. . . domestic capital expenditures for the same 9 months was up 10.9%

. . . earnings of 16 oil companies for the first 9 months of '59 increased an average of 15%.

(over)

Growing foreign markets have resulted in a number of suppliers setting up far-flung sales and service offices . . . Foreign governments are actively soliciting oil companies to explore their resources. Another interesting barometer, The Petroleum Engineer's circulation to engineering-operating men in foreign countries has increased by 50% in the last 18 months. This means over 20% of PE's total circulation is going to engineering-operating men in 79 countries and the figure is growing.

To help you stay directly informed on the international equipment and services market, a "Star Spangled" new feature, GLOBAL NOTEBOOK, began in our December, 1959 issue of The Petroleum Engineer . . . with spotlight on Libya. This series will cover the entire world . . . (but not in Mike Todd Fashion). Rather, each article will dig into the oil business in one country and relate the effect it is having on foreign and world economy. A major undertaking by any editorial standards, GLOBAL NOTEBOOK has all the earmarks of depth reader interest, and particularly to those who sell products and services internationally.

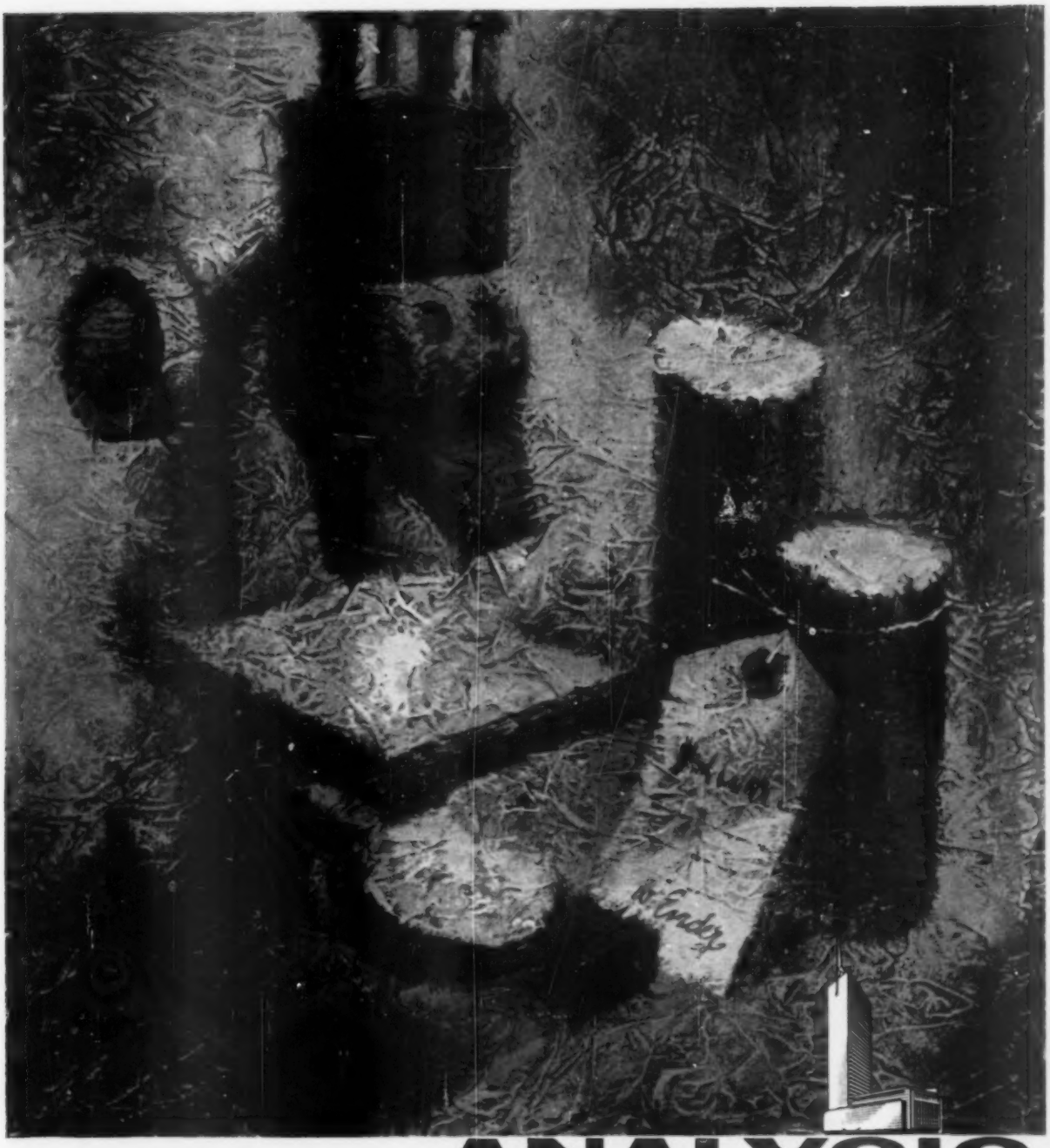
Keep your sales-eye on the new areas of oil development via your complimentary copy of PETROLEUM ENGINEER.

Sincerely,

Abbott Sparks

Abbott Sparks
Advertising Director

(This insert appears only in those copies going to our complimentary list.)



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THE PETROLEUM Engineer

FOR MANAGEMENT

NUMBER 1 • VOLUME XXXII • JANUARY, 1960

Get Ready for the Star-Spangled Sixties A-8

First 100 years are the easiest!... Petroleum industry emerged from limbo in 1959 and faces the first year of the Sixties with expectation and determination ... reports top management. — *Ernestine Adams*

The Conference Table A-16d

"With how little wisdom the world is governed."
— *Oxenstiern*

E SECTION FOLLOWS A

Make Time to Prepare for a Bigger Job E-2

Another article in the "How to be a Manager" series.
— *Chalmer G. Kirkbride*

What Industry Expects of the Engineer E-9

Management knows that growth of our enterprise economy depends upon an ever expanding program of research and development — which in turn depends upon the engineer and scientist. — *Marvin M. Schmidt*

Highlights A-3
The Course of Oil A-4
Advertisers' Index A-6
Management Personals ... E-12
Meetings E-13
The Trade Parade E-16
Books to Read ..... E 22
Laugh with Barney E-23
Of Things to Come in Oil ... B 3
The Oasis B-103
Running Tour with Men in the Industry ..... B 104
Exploration Activities B-106
What's Doing in Drilling ... B-114
Drilling and Producing Equipment B-116
Drilling and Producing Literature B-119
New Refining Equipment ... C-45
New Refining Literature C-50
Refining Personals C-51
Pipeline Projects D-50
Canadian News Notes D-52
With the Pipeline Contractors D 53
Pipeline Personals D-55
New Pipeline Equipment .. D-57
New Pipeline Literature D-60

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The Petroleum Engineer Publishing Company

Indexed by
Applied Science and Technology Index,
The Engineering Index, Inc.,
and Chemical Abstracts
Member of Audit Bureau of Circulation
and Associated Business Publications

The Petroleum Engineer for Management, published monthly, August through June, semi-monthly in July by The Petroleum Engineer Publishing Company, 800 Davis Building, Dallas 2, Texas. Subscription rate to the petroleum industry, United States, Canada, and foreign, $8.00 per year; $14.00 for 2 years; $18.00 for 3 years; $1.50 for single copy. Entered as second-class mail matter May 1, 1932, at the post office in Dallas, Texas, under the act of March 3, 1879. Please send subscription correspondence and change of address to The Petroleum Engineer Publishing Company, P. O. Box 1589, Dallas 21, Texas. Subscribers should notify publisher promptly of any change of address, giving old as well as new address, and including city postal delivery zone, if any. If possible, enclose an address label from a recent issue of the magazine. Allow one month to six weeks for change to become effective.

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DRILLING AND PRODUCING

Outlook for 1960 ... Economy from Improved Techniques B-19

Modern Well Completion Series
Part 3: Conditioning Mud for Well Completion B-22
— *Robert W. Ruhe, Jr.*

Continuous Flow Gas Lift Design B-26
— *Kermit E. Brown and Carlos R. Canalizo*

Sea of Japan Site of First Offshore Oil Strike in the Far East B-31
— *Joseph A. Kornfeld*

New Waterflood Potential in Kansas B-34
— *Edgar L. Leissner*

Production Fundamentals
Part 7: Gas Condensate Reservoirs B-44
— *William C. Goodson*

Independent Advocates Mandatory Pooling B-56

Part 2: Two-Phase Flow in Well-Flowlines B-59
— *Bryan T. Yocum*

Mechanical Aspects of Tubingless Completions B-77
— *Martin E. True and C. B. Corley, Jr.*

Stekoll Steps Up Panhandle Activity B-85

Program of the 4th Annual AOSC Meeting B-86

Interpretation of Air-Drilled Samples B-88
— *John K. Petty*

Southeastern Drills in Iran B-98

Companies with Excellent Management B-113

REFINING AND PETROCHEMICAL

Impact of Computers ... A Problem in Guidance C-6
— *Harry W. Brough*

Optimizing Plant Design C-7
— *A. M. Peiser and M. M. Kessler*

Simulating Plant Studies with Computers C-11
— *D. A. Gibson and E. E. Ludwig*

Integrated Control by Computer C-21
— *Dr. M. Phister, Jr.*

Integrated Data Processing C-25
— *J. W. Haslett and Paul Hodge*

Computers in Process Research and Design C-29
— *Dr. R. S. Davis*

A New Generation in Computers C-31

Reactor and Cracking Furnace Design C-34
— *J. R. Cobb*

OIL AND GAS PIPELINING

Pipe Line Contractors Schedule Interesting Program D-14

Outlook for 1960 ... Pipeline Executives Foresee Good Year Ahead .. D-19

Heavy Equipment Whips Stubborn California Terrain D-25
— *R. E. White*

Pipeline Contractors Directory D-27

Pipeline Fundamentals
Underground Corrosion and Methods of Control, Part 2 ..... D-45
— *O. C. Mudd*

Work Starts on Assam Oil Pipeline D-48

Highlights and footnotes

IMPORT QUOTAS UP . . . CUBA SMOTHERS OIL OPERATIONS . . . GASOLINE SALES TAX FOR MILITARY USE? . . . UNIONS PURSUE ENGINEERS . . .

U. S. Interior Department set imports an average of 79,856 bbl per day higher for first six months of 1960, a total of 1,529,943 bbl per day. IPAA says 1,727,000 bbl per day, counting bunkers, re-exports, Canadian imports. The increase is mostly in fuel oil. Does it come as a surprise to you that 176 companies are importers?

Economic study of percentage depletion recommended by Charles O. Galvin, Southern Methodist University, to House Ways and Means Committee may be the best answer to attackers. But every economist in a consuming state wants to narrow the depletion allowance and those in oil states want broader coverage. That's pretty elastic for economists' reasoning. Almost like politicians' brainwork.

Cuba found the quickest way out of the oil business: Claims must be worked now or relinquished (who'll get benefit of work?); output of refineries is rationed; 60 percent royalty must be paid; concessions limited to 19,000 acres; all information on operations must go to new Cuban Institute of Petroleum. If Cuba has much oil it'll be a long-kept secret.

From Admiral Rickover — *"Work of professional persons in bureaucracies is severely hampered by administrative interference. We have such interferences because we do not draw clear lines between the respective role of the professional man and the administrator and because, of the two, the administrator enjoys the higher prestige and position. He is in fact king."*

ENI was awarded a Libyan concession at some sacrifice by Italy's state-owned company, including higher royalty, no depletion allowance and an option to permit Libyan government to participate. ENI has been aggressively expanding into other countries, creating a new situation—a wholly government-owned business acting as a private agent in a foreign country. Some countries deny entry of firms owned by foreign governments.

Organization of engineers, scientists, technicians, and office workers, *is "most essential organizing task facing the trade union movement"* says Walter Reuther, head of UAW and AFL-CIO. The Industrial Union Department in January will conduct a training institute to educate union staff personnel in problems of professional and technical workers.

Dollar value at latest estimate is 47 cents, with inflation steadying down to a clipping rate of 1 cent a year. The actual value of that $3.01 average you get for a barrel of crude oil is $1.41, about the same as it was in 1946.

Social Security taxes now take 6 percent on first $4800 a year — 3 percent from employer and 3 from employee. Now political plans are for another increase for a compulsory health plan for aged. Trouble with these vote-getting schemes is that you'll have no choice after it's done. Better watch it now.

Competitive leasing of 1,608.000 acres of submerged land in the Gulf will be offered February 24 by U. S. Interior Department. Title to some areas is still in dispute with states; Supreme Court expected to decide soon. Odds look like 60-40 for U. S.

Tax testimony before House Ways and Means Committee is drawing some good witnesses. Said Cornell University's economics prof, M. Slade Kendrick: *"Corporations are doing business primarily for the benefit of the Federal Treasury."*

How times change! Investment wiseacres are advising the public to buy oil stocks for income now since prices are so low. Once we were told to buy for appreciation. Are we getting old and proper?

Petroleum companies answered a request to guarantee Venezuelan government treasury bills for $100 million. The bills will go to New York banks for dollars needed by the government. Oil companies will purchase them at maturity and exchange them for bolivars. Companies have had a request for a second $100 million on the same terms. Sounds like a Venezuelan Soapy Williams regime.

Here's a final: Bureau of Mines reveals 1958 figures in December 1959. U. S. production was 6,710,-000 bbl per day, down 6.9 percent . . . prices went from $3.09 in 1957 to $3.01 average at well in 1958. Domestic demand was up 3.0 percent. Maybe because we're deadline happy, we think 11 months is too long to collect this data. Can't Bureau of Mines nick Uncle Sam for a computer?

Higher bridges finally brought into focus what oil men have been talking about all along. Military services want bridges on new interstate highways to be built higher to give certain weapons clearance. The highway fund, supported by excise taxes on oil products, may be obliged to pay the extra $1 billion cost for military objectives. Shouldn't every one pay for security measures?

One statistical report bit the dust! Hopeful sign is cancellation by Bureau of the Budget of its plan to launch a program of annual surveys of oil wells and minerals. Industry pointed out it would not use report and government didn't need it so it was dropped.

Concentrated battle point in next Congress will be National Fuel Policy. Coal industry wants to regain lost markets by federal legislation. Petroleum industry wants competitive markets. Argument for: We're running out of oil and gas. Argument against: We'll have oil and gas when sun energy will be cheaper. Why use high-priced inconvenient coal now?

WANTED:

More Thrust Power

THE PETROLEUM INDUSTRY has closed a hundred years of dynamic thrust. In that brief time we've transformed the world. We've penetrated every business and industry on earth. In the United States alone we collect some $45 billion a year and pay it out again. We do the biggest service in the nation for the smallest charge.

Are we happy? Good heavens, NO!

We're overloaded with a sea full of barnacle-encrusted troubles that we carry along instead of doing a cutting and cleaning job. If the problem gets big and tough, like a war, we barge through with direct, concerted action that sweeps obstacles right and left; but give us a plain, everyday obstruction and we'll nurse it for 30 years. We sit and moan over it while it grows and grows, then join a committee to groan in harmony.

WE HAVEN'T GOT A PROBLEM that we can't solve. We're over-supplied, over-taxed, over-controlled. We can't wipe out all these extras overnight but we can do more scraping at all three. We didn't energize the world following our own small ruts. We looked to a glowing horizon and put the kind of power into our progress that shoots a missile to the moon.

Has our dynamic youth run out? Have we grown too big to move decisively? Are we going to bicker among ourselves while new energies take the field?

The 'Sixties are launched — forecast as fabulous — and with it our second hundred years. It is up to us what we do with them. We can wallow clumsily carrying our parasite-problems, or we can soar ahead breaking new barriers.

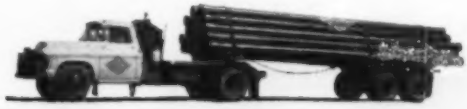
Our power thrust is being measured. It depends on our I-N-D-I-V-I-D-U-A-L count-down.

Ernestine Adams

Congrats and $25 for this quip to CAROLYN KENEDY, Bells Wells Oil Company, Box 269, Miami, Oklahoma.

When it comes to shapeliness . . . Lone Star pipe proportions are right! All dimensions and qualities are strictly API specifications.

Lone Star Steel . . . America's most modern pipe plant . . . is Joe Roughneck's solid source of supply. Right here in the center of the oil country . . . quick availability of Lone Star pipe is a terrific convenience.



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THE PETROLEUM
Engineer
FOR MANAGEMENT
INTEGRATED EDITION OF THE PETROLEUM ENGINEER

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Advertisers' Index

— A —
ACF Industries, Incorporated—W-K-M Division A16a, B-58
Aero Service Corporation B-117
Ajax Iron Works B-8
American Machine and Foundry Company, The J. B. Beaird Company, Incorporated, Subsidiary B-111
American Recording Chart Company D-57
Antara Chemicals, A Sales Division of General Aniline & Film Corporation B-93
Automatic Electric, Subsidiary of General Telephone & Electronics D-11

— B —
Babcock & Wilcox Co., The Tubular Products Division C-56
Baker Oil Tools, Inc. B-18, B-38, B-39
Baroid Division, National Lead Co. B-99
The J. B. Beaird Company, Incorporated, Subsidiary, American Machine and Foundry Company B-111
Bendix Computer Division of Bendix Aviation Corporation C-49
Bethlehem Steel Company D-4, D-5
Brakesol, Inc. B-120
The Brewster Company, Inc. B-101, B-102

— C —
Cabot Shops, Inc. B-1
Cameron Iron Works B-80
Caterpillar Tractor Company E-17
Classified Advertising E-23
Collins Radio Company D-7
The Colorado Fuel and Iron Corporation B-12
Conco Chemical Co. D-61
Continental Oil Company B-50
Continental-Emsco Company, a Division of The Youngstown Sheet and Tube Company B-4
Cooper-Bessemer Corporation C-32, C-33, D-12, D-13
Core Laboratories, Inc. B-107
Crane Packing Company C-46

— D —
Daniel Orifice Fitting Company, Incorporated E-22
Darling Valve & Manufacturing Co. D-3
Dayton Industrial Products Co., a Division of Dayton Rubber Company B-66, B-67
De Laval Steam Turbine Company C-52, C-53
Dempster Brothers, Inc. E-20
Dodge Manufacturing Corporation B-17
Dowell ..... Inside Front Cover, A-15
Drilling Accessory & Manufacturing Co., Inc. D-56
Du Pont, E. I., de Nemours & Co., Inc. C-39, C-47, C-48

— E —
Engineered Oil Tools, Inc. B-61
Ethyl Corporation C-4, C-5

— F —
Fleetline Co. D-61
Fluid Packed Pump Co., a Division of The National Supply Company B-96, B-97
The Foxboro Company D-16
Franks Division of Cabot Shops, Inc. B-6, B-7

— G —
Gardner-Denver Company B-112
Garrett Oil Tools, Division of U. S. Industries, Inc. B-71
Gase Pump & Burner Mfg. Co. D-51
General Electric Company C-18
General Hermetic Sealing Corp. E-23
The Goldak Company D-42
Grove Valve & Regulator Company, a Subsidiary of Walworth E-11
The Guiberson Corporation B-13

— H —
Halliburton Oil Well Cementing Company ..... B-43, B-57, B-92, Back Cover
Harbison-Fischer Mfg. Co. B-85
Hardy-Griffin Engineering Corporation, a Division of Atlas Pipe, Inc. B-118
The Harshaw Chemical Company C-3
Hercules Powder Company C-51
Hercules Tool Company B-110
H & L Tooth Company A-16f
H & M Pipe Beveling Machine Company D-58
Houdry Process Corporation C-40, C-41
Houston Contracting Company D-18
Houston Oil Field Material Company, Inc. B-89
Hunt Tool Company B-90
Hydril Company B-35

— I —
Ingersoll-Rand D-10
Insley Manufacturing Corporation D-8
International Business Machines C-54, C-55, E-18

— J —
Jensen Bros. Mfg. Co. B-105
Johnston Testers, Inc. B-45
The S. M. Jones Company, Division of Buffalo Eclipse Corporation B-55
Jones & Laughlin Steel Corporation D-36, D-37

— K —
Klampon Corporation B-105
KLM Royal Dutch Airlines E-7

— L —
Lane-Wells Company ..... Inside Back Cover
Lenape Hydraulic Pressing & Forging Co. C-45
J. E. Lonergan Co. E-3
Lone Star Steel Company A-5
Lufkin Foundry & Machine Company B-5
The Lufkin Rule Company E-23

— M —
Magnet Cove Barium Corporation B-41
Manufacturers Engineering & Equipment Corporation C-50
Marsh Instrument Corporation, Division of Colorado Oil and Gas Corporation E-5
John N. Martin, Manufacturer B-15
Mayor-Kelly Company D-52
Merla Tool Corporation B-119
Miller Sand Pump Co. B-120
Milwhite Mud Sales Company B-70
Mission Manufacturing Co. B-87
M & V Tank Company B-120

— Mc —
McCord Corporation D-61
McCullough Tool Company B-9

— N —
The National Supply Company B-51, B-52, B-53, B-54
National Tank Company E-24
W. C. Norris, Manufacturer, Division of Dover Corporation B-94, B-116

— O —
Oakite Products, Inc. C-10
Oil Center Tool Co. B-49
Oil Well Supply Division of United States Steel A-7, B-37
Orbit Valve Company B-10
Otis Engineering Corporation B-91

— P —
Pan Geo Atlas Corp. B-16
The Parkersburg Rig & Reel Co. B-62, B-63
Parsons Company D-55
Petreco a, Division of Petrolite Corporation A-16a
Petroleum Electric Power Association E-15
Pipeline Cleaners Co. D-81
Pipe Linings, Division of American Pipe and Construction Co. D-54
Polyken Products, Division of The Kendall Co. D-17
The Wm. Powell Company A-16b

— R —
Radiator Specialty Co. C-50
Rector Well Equipment Company, The B-74
Reed Roller Bit Company B-72, B-73
Reilly Tar & Chemical Corporation D-47
Republic National Bank of Dallas A-1
Rockford Clutch Division, Borg-Warner B-113
Rockwell Manufacturing Co. B-100
Roebling, Subsidiary of The Colorado Fuel and Iron Corporation E-8
Rust-Oleum Corporation E-14

— S —
Schlumberger Well Surveying Corporation B-83
Security Engineering Division B-69
Shaffer Tool Works B-108, B-109
M. B. Skinner Co. C-51, D-42
Spang & Company B-104
Standard Pipeprotection D-44
Steel Forgings D-60
Stephens Engineering B-117
Sun Ship Building & Dry Dock Co. C-1

— T —
The Tapecoat Company D-6
Teletype Corporation, Subsidiary of Western Electric Company, Inc. D-1
Texas Instruments Incorporated C-28
The Thompson-Rame-Wooldridge Products Company C-44
Thornhill-Craver Company D-2
Tretolite Division, The Petrolite Corporation B-75
Tyson Smith Co. B-84

— U —
Union Switch & Signal Division of Westinghouse Air Brake Company D-9
Universal Oil Products A-16h, C-43, C-44

— V —
Henry Vogt Machine Co. A-16c

— W —
Waukesha Motor Company B-11
Welex, Inc. B-2
Well Reconnaissance, Inc. B-103
The Western Company B-65
Western Gear Corporation, Industrial Products Division D-62
The Wheland Company B-14
Wichita Engineering Co. B-120
Williams Pressure Service Company D-59
T. D. Williamson, Inc. D-43
Wilson Manufacturing Co., Inc. B-114, B-115
W-K-M Division of ACF Industries, Incorporated A-16a, B-58
Wolverine Tube Division of Calumet & Hecla, Inc. C-37, C-38

— Y —
Yarnall-Waring Company C-2

THIS INDEX IS PROVIDED AS AN ADDITIONAL SERVICE FOR OUR READERS
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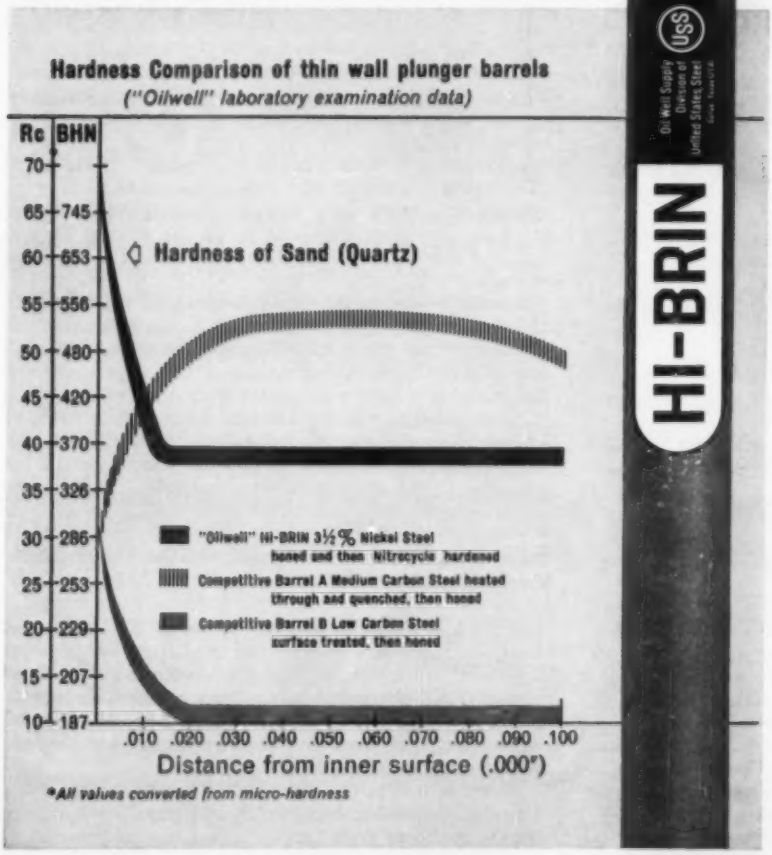
"Oilwell" Hi-Brin Subsurface Pump Barrels are hard where it pays to be hard

...at the wearing surface!

LOOK . . . at this photomicrograph! A cross section of "Oilwell's" HI-BRIN Pump Barrel, magnified 250 times, shows the hardness of the barrel interior and the white layer of superhard nitrides. The smallest black impression made by the hardness tester shows a Rockwell "C" hardness of 68.



Examine this hardness comparison chart for a moment . . . and you'll see the performance secret of "Oilwell" Hi-Brin Subsurface Pump Barrels.

The secret is *controlled* hardness!

Compared with competitive barrels, the inside surface of Hi-Brin Barrels is harder to begin with . . . and STAYS harder right through the point (about .006" on the radius) where fluid slippage, due to wear, makes pump replacement necessary. Extreme hardness drops beyond this point . . . keeping intact the inherent toughness of the alloy steel tube.

Through "Oilwell's" exclusive distortion-free process, Hi-Brin Barrels are finish honed BEFORE hardening, so that the layer of superhard nitrides remains on each barrel's inner surface to greatly retard the rate of wear.

Hi-Brin Barrels are extremely resistant to hydrogen sulfide corrosion and to the abrasive action of sand. They contain 3½% nickel for extra toughness.

Contact your "Oilwell" representative or visit your "Oilwell" store for more information about Hi-Brin Pump Barrels. Try one in your next well. Your first Hi-Brin Barrel will certainly lead to more.

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First 100 Years Are the Easiest

GET READY FOR THE *STAR SPANGLED SIXTIES*

PETROLEUM INDUSTRY EMERGED FROM LIMBO IN 1959 AND FACES THE FIRST YEAR OF THE SIXTIES WITH EXPECTATION AND DETERMINATION . . . REPORTS TOP MANAGEMENT

Ernestine Adams

YOU'VE JUST COMPLETED a decade of unbelievable progress. You've just closed the door on the fabulous fifties. The petroleum industry took a steep climb to dizzy heights.

U. S. demand went from 6 million bbl a day in 1949 to about 9.5 million in 1959.

Annual capital expenditures nearly doubled in 10 years.

Gross investments in one decade almost doubled, too, — from $30 billion to nearly $60 billion.

Wells drilled grew from 38,000 wells to about 52,000 wells a year.

Refinery capacity expanded from 6.7 to 9.7 million bbl a day.

Petrochemicals quadrupled in volume during the fifties. Production now totals 40 billion lb annually. Its value — $5 billion.

Crude and products trunkline operations increased 72 percent to 3.8 billion bbl in 1959. Investment is now $3 billion — compared to $1.6 billion in 1949.

Gas transmission lines have doubled to 190,000 miles in 1959.

THE BEST PROMISE of 1960 is that the industry is better prepared to meet its changes and challenges than ever before.

Last year was a crucial one. There was a great deal of preparation for better management. Here are some of the things that were done:

1. *Mergers strengthened several companies working toward integrated operations.*
2. *Reorganizations in large companies brought and is bringing greater efficiencies.*
3. *Planning of operations was more carefully done with an eye on profit margins.*
4. *Research was pushed despite the stress on economy.*
5. *Petroleum management faced fully the problem of political action and many companies incorporated a political program as part of their responsibility.*

The point here is not that problems are less but our ability to deal with them is improved and bolstered.

You can see evidence, too, that our moral courage is firmer. There was response to the plea for lower refinery runs. Management *is* concerned with all the industry and with national security as well as its individual company.

FOR THE SHORT-TERM, industry economics depends primarily on labor—the steel strike, now under injunction, the probable railroad strike with even greater effect on petroleum, and other potential strikes. We are more dependent upon a few labor union leaders for our economic welfare this year than upon ourselves or government or even consumers. Until unions are placed under some anti-monopoly control, our economic lives will hang on the nod of a labor leader.

A longer view places a heavy responsibility on the U. S. oil industry. Remember this: *Population of the U. S. is increasing at a more rapid pace than that of India.* Unless we want our living standards to go the way of India's, we need more capital and better equipment to increase productivity.

Recently Chase Manhattan's "Business in Brief" stated: The stock of capital assets in use increased 40 percent between 1948 and 1957, while manhours rose only 4.5 percent. The rise in output per manhour, then, largely reflected the gain in efficiency which came from using more capital.

The petroleum industry has vital need of great funds of capital. Much of it must be raised by the companies through profits because they cannot go too often to the public for financing. Profit margins widened slightly in 1959. One objective of 1960 is to increase the spread. With such an oversupply of oil and oil products as we now have, we must keep reminding ourselves that the oil we use is irreplaceable except at greatly increased costs.

CAPITAL OUTLAYS in 1960 by the U. S. industry for foreign and domestic reserves and fixed assets will be about 2 percent higher than in 1959. Our estimates are based on reports from companies whose expenditures amount to about half the total. There are no particular trends. Managements of individual companies apparently are carefully custom-making expansion plans.

As we've said before in estimating capital outlays, there are no strict dividing lines used by all companies. Estimates for the last three years are:

Miss Adams is Management Editor.

1960 Trends . . .

U. S. DOMESTIC DEMAND UP 4%. *A year ago our long-range-around table came up with a 5% increase for 1959. This will come within a fraction of actual demand. Bureau of Mines reports 5.6% above 1958 for first nine months. Prediction for 1960 is a 4% rise. Range of estimates by forecasters are from 3.5 to 5%, with majority settling for a straight 4%.*

U. S. EXPORTS MOVE DOWN. *This appears to be a long-term trend. Consensus is that lower exports will bring total demand down to 3.7% in 1960. Range was from 3.3% (quoting IPAA figures) to 4% rise in 1960 of total U. S. demand.*

FREE WORLD DEMAND UP 7.5%. *Majority of forecasters named 7% rise for oil consumption in free world outside of United States. This was also the minimum increase suggested; other estimates went as high as 10%.*

PRICES STEADY. *Prices of both crude oil and products are expected to hold pretty firm for at least the first half of the year. Producers are worried about crude and refiners about products prices, but most oil men believe any changes will be in a narrow range.*

U. S. PRODUCTION UP 5%. *Consensus is that another substantial production increase is due in 1960. Range of forecasts were from 3 to 6%, with few outside the 5% estimate. Last year's prediction was a 6-7% increase in 1959 over 1958. Bureau of Mines shows a 7% rise in first nine months.*

REFINERY RUNS UP 3%. *Not many took a guess on this one, but the few were pretty much in agreement on the 3%. In first nine months of 1959 runs increased 6.4% compared to 5.6% demand for products, which is credited with increasing inventories and keeping prices on weak side.*

CAPITAL OUTLAYS UP 2%. *Companies whose expenditures amount to about half the industry's total outlays for facilities and exploration, report a 2% rise over 1959. This estimate is to a high degree subject to change. If 1960 improves as the majority expects, capital expenditures and exploration will edge up.*

CAPITAL EXPENDITURES

U. S. Industry Here and Abroad	1958	1959	1960
Drilling and Production	$ 4,469 million	$ 4,760 million	$ 4,845 million
Manufacturing (Including Petrochemicals)	1,041 "	1,260 "	1,230 "
Transportation (Not Gas Transmission)	455 "	410 "	420 "
Marketing	688 "	750 "	810 "
Other	157 "	140 "	170 "
Total	6,810 million	7,320 million	7,495 million
Foreign (U. S. Industry)	1,500 "	1,790 "	1,865 "
Domestic (U. S. Industry)	5,310 million	5,530 million	5,630 million
Foreign (Free World)	5,400 "	5,700 "	6,000 "
Total Free World	$10,710 million	$11,230 million	$11,630 million

The table indicates the heavier balance of capital expenditures have swung outside the United States to other countries in the free world. Communist countries are undoubtedly putting huge sums into building their oil and gas industries.

"THE OIL BUSINESS is not as bad as the Wall Street Journal would indicate," asserted the president of a producing company.

And that's the idea you'll get from the comments and forecasts of the men who know best — top management of big and small companies.

There is, however, a repeated call for industry statesmanship to keep supplies in balance with demand. One executive said we needed "industrial heroism" — a pretty exact description of what 1960 is going to demand of petroleum management.

The president of a domestic integrated company writes:

"1960 will be a good year for the industry if the persons directing the destiny of the larger companies show a slight amount of restraint and moral leadership. Each company should process whatever amount of crude oil is necessary to meet the market demand for their products. They should respect the contracts of other companies and eliminate the bootlegging of gasoline into the other fellow's contracted account, to be sold under the other fellow's brand. To do this, they should police the destiny of their mechandise. It is a simple matter, but if carried out we would set a good example in business statesmanship."

Other petroleum executives have their opinion of the future. Here are some:

Runs Must Be More Realistic

J. L. Sewell
President
Delhi-Taylor Oil Corp.

DOMESTIC CRUDE OIL production in 1959 was reasonably well in line with demand but should show improvement in volume in 1960 due to the restraining effect of import control.

Refinery runs were excessive during the first nine months of 1959, requiring drastic curtailment during the fourth quarter. Although this duplicated the industry's 1958 performance of overproduction, it is hoped that 1960 refinery runs will be scheduled on a more realistic basis. If so, an improvement in market conditions will result.

We expect domestic demand for refined oils to increase some 3 to 4 percent. Our thoughts on foreign demand are not sufficiently crystallized to venture an opinion at this time.

It is hoped that crude oil imports will be held at present

volumetric levels, thereby dedicating to the domestic producer all of the increase in domestic demand. This would allow the domestic producer to regain some of the position lost through the drastic curtailments suffered during the past two years.

With regard to transportation we feel that excess tanker capacity will continue to result in depressed rates.

Continuing excess of refinery capacity and tendency of the industry to use this to the detriment of refined oil market prices is one big problem we face in 1960. Another is continued turmoil and confusion in the regulation of the natural gas producer by the Federal Power Commission.

Upgrading Will Be Biggest Concern

Ray L. Tollett
President
Cosden Petroleum Corp.

THERE WILL BE MODEST increases in domestic production during 1960 to meet expansion in demand, which will require approximately a 3 percent increase in refinery runs. Expansion of gas transmission pipeline systems will continue, but no increases are in prospect for extension or expansion of pipelines for transportation of crude oil and products. I do not believe that the mandatory control of imports will be modified upward, except perhaps in the instance of residual fuel oil.

The year 1960 is sure to be remembered for lower refiner's margins on processing and marketing. In my opinion, domestic crude oil prices are now and will continue to be reasonably firm at present price levels. Refiners will be squeezed because of excess in refining capacity. Moves to restrain ambitious sales programs and limit refinery runs will be announced from time to time; but until domestic demand catches up with present refining capacity and shows an increase, product prices will remain depressed.

Oil industry managements will next year be principally concerned with reducing the cost of acquiring crude oil reserves and improving efficiency of refining facilities, which includes upgrading to the very limit each fraction of every barrel of crude oil processed.

Industrial Heroism Needed Now

W. S. Hallanan
President
Plymouth Oil Company

FOR INDEPENDENT domestic oil companies, the year 1960 looms as a battle-ground for survival. Any operator within that classification who views the new year in any other light is courting disaster.

While there are a few signs of improved conditions, they are far outweighed at the moment by other factors which indicate the industry will continue throughout 1960 to be plagued by oversupplies of crude and products with consequent peril to a price structure that already stands upon the brink of the suicide level.

Most discouraging aspects of the entire situation is the inability or refusal of the majority of domestic refiners to bring their runs down to realistic levels. While I would not wish to set our own company up as an example of restraint, I must observe that if every other domestic refiner cut runs in the same proportion as we have, there would be no problem of price and supply of products. For months our refinery has operated at 60 percent of capacity.

The time has passed for what we need to call industrial statesmanship. The industry failed to measure up to that challenge with the result that it is now face to face with the necessity for industrial heroism. I mean the kind of heroism that sells the hour to serve the day. We must look beyond the potential profit of a single month or quarter, and gear our objective to a long-range future. It is of no profit to reduce today's unit cost of products if the result is to be, as inevitably it will, a crumbling of the price structure tomorrow.

Although the domestic industry as a whole has not yet been willing to face up to realities, I find a ray of hope in the belief that the sheer weight of its burdens will compel the kind of readjustment necessary to its preservation.

The question of survival is squarely up to the industry itself.

Balanced Operations Vital

L. F. McCollum
President
Continental Oil Company

OPERATIONS IN 1960 may be termed "good," even though many phases of the industry may not have been at as high a level as would be desired. In retrospect, we find that the volumes are at strong levels but that prices have been depressed. Excess product inventories indicate that the refinery portion of the industry operated at too high a level (up 6.5 percent from 1958) in relation to a total demand increase of 4 percent. Other basic data on 1959 show a domestic demand increase of about 4.5 percent and a crude oil production increase of about 6 percent.

With an increase of 3.5 percent in domestic demand for 1960 as compared with 1959, a balanced operation may be achieved with a refinery runs increase of 3.7 percent and a crude oil production increase of 3.9 percent. This balance which was computed in light of a realistic look at operations will not necessarily cure all the present ills of high inventories.

Major problems facing the domestic industry will be continued high product inventories and resulting price weaknesses. This will be accentuated by the present imbalance of stocks within and between various geographic areas. Excessive distillate stocks on the East and Gulf Coasts (PAD Districts I and III) will require a "colder than normal" winter in order to prevent a large carry-over at the end of the season. At the same time, we find an unseasonally strong gasoline position in the same area. Geographically the situation in the Mid-Continent area (District II) reverses the picture — low distillate stocks and high gasoline stocks.

The solution is obvious — reduce runs, shift yields, and balance refinery operations with demand. However, history shows us that this is much easier said than done. The temptation to use the excess refinery capacity available will be with us for at least a couple more years, until demand catches up with refinery capacity. Also, in the scramble for markets each refiner is producing products to "put on the shelf" for sale in expanded marketing areas, thus intensifying competitive factors.

OUTLOOK: INCREASED DEMAND WILL HELP TO LIGHTEN OVERSUPPLY.

Stabilized Supply Can Come in 1960

R. G. Follis
Chairman of Board
Standard Oil Company
of California

THE U. S. PETROLEUM industry in 1959 experienced a favorable demand performance, but at the same time, prices were generally weak. Domestic demand exceeded 1958 by 5 percent. Crude production gained nearly the same percentage. However, product and crude prices progressively deteriorated through the year, with prices in some areas falling below 1953 levels. Oversupply was the principal factor bringing prices down.

Domestic demand is expected to rise 4½-5 percent in 1960 over 1959. With import controls operating for the first full year, a greatly stabilized supply outlook can be expected if the industry keeps a close check on supply, particularly during seasonal swings in demand. Domestic crude production can rise by 5 percent, accommodating both a rise in demand plus a further modest drawdown in inventories. Under these conditions, light product prices will strengthen, and refiners' margins can be improved to near normal levels. Improvement in crude prices, although justified because of rising costs, does not seem too likely in 1960, especially in the early part of the year.

Free foreign demands are expected to be up about 8 percent in 1959 vs 1958 with a similar healthy gain next year. 1960 should witness a marked pick-up in demand in the primary raw material producing countries as economic conditions in consuming countries continue to improve. Also, the underdeveloped areas should show marked percentage gains even though the volume gain may be small.

The tanker market holds little promise for a marked strengthening in rates until shipping needs catch up with tanker availability. Periodic strengthening may come in 1960, but owing to the sizable portion of the fleet in lay-up, no strong advance in rates is expected.

Demand Increase Will Ease Inventory

Gordon Simpson
President
General American of Texas
and of IPAA

AN EXPECTED UPTURN in all branches of the oil business during 1959 has either failed to materialize or has been less marked than had been hoped. However, slowly improving conditions currently warrant the prediction of a better 1960. Rig count and other indices ndicate 1959 to have been somewhat better than 1958, an improvement that is reasonably expected to continue.

An oversupply of crude oil at home and abroad will no doubt be among leading problems facing the industry in 1960. IPAA predicts an increased demand of some 3.4 percent in 1960. If this increase materializes, it will go far to bring about a more healthy inventory balance. This depends, of course, upon a continued restriction of oil imports by the federal government. Domestic demand should increase about 3.5 percent in 1960 and world-wide demand about twice that figure. Obviously, this makes for a better outlook.

Pessimism Has Been Overstated

James R. Wendover
President
Nortex Oil and Gas Corp.

THE OIL INDUSTRY has been complaining bitterly about present conditions but it appears to me that they have somewhat overstated the case. The oil business is not as bad as the Wall Street Journal leading articles would indicate. There is certainly an excess of supply but this is only typical of the cyclic nature of the industry.

Demand throughout the entire world continues to rise each year and should balance with supply within the next 4 or 5 years. I do not look for 1960 to be appreciably different from 1959.

Excess available supply will be the chief problem for the next few succeeding years. I see no prospects of solving this problem until demand catches up.

Turning Point in 1960?

Wm. Wallace Main, Jr.
Chairman
Bishop Oil Company

THE 1959 OPERATIONS for most domestic crude oil producers were the poorest in many decades. The 1960 potential follows:

1. U. S. production should increase slightly above the low of 1959;

2. Domestic demand should increase approximately 4 percent; foreign demand, 9 to 10 percent.

We believe that 1960 will be the turning point for U. S. producers toward a better future in production as well as crude oil prices.

World overproduction resulting in the continued lower prices will trouble the industry far into 1960. It certainly should be possible to solve such problems by international agreements with other producing countries to eliminate surplus crude oil and thus stabilize and/or increase the price of crude oil to its reasonable and fair value. What is especially needed is an upward adjustment of prices to keep pace with rising costs.

Predicts U. S. Demand Up Another 4%

Fred W. Bartlett,
Chairman
Socony Mobil Oil Co., Inc.

DEMAND FOR OIL products in 1960 will increase over 1959 by about 4 percent in the United States and by about 7 percent in the remainder of the Free World, our economists estimate. Domestic increase in 1959 has been about 4 percent; the increase for the rest of the Free World, about 7.5 percent.

Economic problems include:

1. Oversupply, resulting from excess crude oil producibility, excessive U. S. refinery runs and surplus tanker tonnage.

2. Slimmer profit margins, stemming from oversupply and from sharpening competition in an already severely competitive industry.

3. Continuing sizable capital investments, even if on

a reduced scale, in a time of reduced profit margins.

4. Rising costs and threat of further inflation.

Main political problems – often inseparable from economic difficulties — embrace:

1. Misunderstanding of, and consequent attacks on, percentage depletion.

2. Federal regulation of the wellhead price for natural gas under utility-type controls.

3. Certain features of the oil import regulations, such as government surveillance of prices in a strongly competitive industry.

4. High taxes on gasoline.

5. Special-interest pressures for further government intervention in the form of, for example, end-use controls.

6. Political (and economic) instability in many countries.

7. Growing pressure for refining facilities in consuming countries beyond the point of economic efficiency.

Many of these problems, ironically enough, stem from the very success of privately owned oil companies in assuring adequate supplies of raw materials and the refined products that people need and want. The solution, or alleviation, of these problems lies at least partly in increased public understanding of our business.

Estimate Free World Demand 5.7% Up

IN THE TABULATION which follows we show our current estimate of the 1960 increases in the operations of the petroleum industry in comparison with 1958, and our present estimate of 1960 increases.

Augustus C. Long
Chairman
Texaco, Inc.

DEMAND SUPPLY OUTLOOK
Percent Change

	1959 over 1958	1960 over 1959
Demand		
United States	4.3%	3.7%
Free Foreign	8.6%	8.0%
Total Free World	6.3%	5.7%
Crude Production		
United States	6.0%	5.4%
Free Foreign	8.0%	6.6%
Total Free World	7.1%	6.1%
Refinery Runs		
United States	5.3%	5.7%
Free Foreign	9.9%	6.7%
Total Free World	7.6%	6.2%

Among problems confronting the industry in 1960 will be the excess producing and refining capacity which has now been built up. But, it is not uncommon to have some surplus or shortage in an industry as intensely competitive as the oil business. We expect the increased demand during the years ahead to absorb the present excess capacity without serious disruption to the industry.

It seems certain that the coming year will reflect continually increasing competitive pressures, and require an even greater need for operations to be conducted at peak efficiency.

Prospects of continuing inflation resulting largely from ability of organized labor to force wage increases substantially exceeding gains in the wage earner's productivity, is another serious problem the petroleum industry may face in 1960.

Another problem facing the industry in the coming year is the uncertainty caused by the continued attacks on the 27½ percent depletion allowance. We are doing everything practicable to make the consuming public and our elected representatives realize that (a) only income from capital should be taxed, and not capital itself; (b) the depletion allowance is a reasonable and needed incentive to producers to continue the costly and risky search for petroleum; and (c) a reduction in the depletion allowance would jeopardize the future supply of this low cost energy which is essential to both economic progress and national defense.

Plans for Future Energy Needs

H. S. M. Burns
President
Shell Oil Company

DESPITE A CURRENT surplus of crude oil, world-wide, the industry's major task in the long run will be to find enough oil to meet the world's growing need for energy.

Accordingly, Shell's capital expenditures for 1960, which will be higher than in 1959, will emphasize programs for developing crude oil production. An important part of this work will be done in the Gulf of Mexico off the Louisiana coast.

Shell does not plan any refinery expansion for 1960 but may make some changes in order to upgrade heavy products.

As for the industry-wide picture, we expect total domestic demand for all oils to be about 4 percent higher in 1960 than in 1959. Gasoline demand will be up about 4 percent, intermediates will be up somewhat less than 4 percent, and residuals up about 2 percent. Demand for other products, including commercial jet fuel, is expected to increase about 6 percent.

Crude oil production is expected to reach a new peak in 1960 of about 7,400,000 barrels a day, or 5 percent more than in 1959.

Need Critical Reviews of Expansion

W. K. Whiteford
President
Gulf Oil Corporation

THE YEAR 1959 PROVED to have mixed consequences for the petroleum industry. Domestic production showed some improvement over the depressed rate of 1958, but fell short of the peak rates of 1956-57. This reflects the industry's concerted efforts to eliminate excessive stocks at the producing end of the business.

The manufacturing segment of the industry has not been as successful in restraining operations, however, and crude runs will average about 7,950,000 barrel daily for the year, which will be a record annual level. This precludes any significant adjustment to total stock levels. Unfortunately, it is indicated that substantial additions were made to refinery capacity in 1959, which undoubtedly was some stimulus to over-running of crude. The industry must review its operating rates critically if present stock excesses are to be eliminated.

The most critical problems confronting the industry stem from excess capacity in almost every segment of the industry, more acutely in the U. S. perhaps, but generally worldwide. Anticipated growth in demand will ameliorate some of these problems, but demand gains experienced in the immediate postwar years will not be duplicated in the

future. Consequently, the only means to accelerate an adjustment of excesses in capacities and stocks is for industry to plan further expansions only after critical reviews.

In the U. S., petroleum demand should show a gain of three to four percent in 1959 over 1958, in spite of the steel strike. This is partially a reflection of the depressed demands experienced during 1957-58 when general business activity was off-pace. We look for another four percent gain in 1960, in response to a general environment of high business activity particularly if the economy is not unduly disrupted by any major work stoppages in 1960.

Automotive gasoline demand should demonstrate significant strength in 1960 and offset a continued decline in aviation gasoline so that gasoline in total should show about a three percent gain over 1959. Middle distillates should show a modest gain in 1960, while residual could also record a substantial gain if supply is readily available. Good growth in other products should also be obtained during 1960. Petroleum demand outside the United States will likely be on the order of double that experienced in the United States.

The most urgent problem facing the industry in 1960 will be that of realistically maintaining supply in line with anticipated demands, less desired stock adjustments, to provide a basis for improved price realizations which will be necessary if the industry's profit position is to be maintained.

This favorable result, if obtained, will then help resolve another basic problem confronting the industry, and that is the maintenance of adequate reserves. Recognizing that the extension and development of U. S. reserves has steadily increased in cost over the years, and will likely continue to increase in the future, it is more apparent that the profit position of the industry must be maintained.

Better Earnings Position Possible

Robert G. Dunlop
President
Sun Oil Company

IN 1960, FIRST YEAR of the oil industry's second century, it is estimated that domestic and export demand for oil will pass the 10 million barrel daily figure for the first time.

Our studies also indicate the probability of a general improvement in the industry's inventory position, and a possible strengthening of the product price structure.

In surpassing the 10 million barrels daily mark, total demand will top 1959 by about 3.5 percent. Export demand will be off slightly, but domestic demand is expected to increase by almost 4 percent. This gain — only slightly less than the average annual increase since 1950 — coupled with the expectation of a partial recovery of prices indicates an improved outlook over the year.

Contributing to the higher level of oil operations will be the anticipated increase in general business activity throughout the economy. It is estimated that both gross national product and industrial production will show increases in the neighborhood of 6 percent over 1959.

To support the level of petroleum demand projected for 1960, it is estimated that crude runs to stills in U. S. refineries will increase by some 4 percent. Domestic producers of crude oil can expect a similar gain. Assuming no major change in Government crude oil and product import allocations, domestic production of crude oil and natural gas liquids should show an increase of 4.5 percent in 1960.

Although it is hoped 1960 will bring a higher level of operations and a better earnings position for the industry, there are several problem areas on the horizon.

Inventories will continue to be a basic problem within the industry. Although a better supply-demand balance should be achieved during the coming year, the world oversupply of oil will continue to depress product prices for some time to come. To meet this problem, the industry must continue to exercise restraint by gearing operating levels to indicated demand, and must continue to search for new methods of increasing efficiency and reducing costs.

Outside influences which will affect the industry's economic position in 1960 are primarily two — rising gasoline taxes, and continued regulation of natural gas prices.

Sharp competition within the industry has kept gasoline prices low in relation to the general price level in the postwar period, but rising gasoline taxes have steadily pushed up the price to the consumer.

Regulation of natural gas field prices by FPC seriously interfered with the normal economic functioning of the industry in 1959 and the situation will be even more troublesome in 1960. Such regulation has generated a king-size headache — compounded of uncertainty, confusion and unnecessary expense — for the gas producer, and is posing a serious threat to future gas supplies for consumers.

It has been estimated that capital spending by the industry in 1960 will total $5.15 billion, slightly less than the 1959 figure. The decrease stems from a cutback in drilling and production outlays, in the face of the continued world surplus of crude oil.

Lower Crude Prices Helps No One

Jake L. Hamon
Independent
Dallas, Texas

ASSUMING THAT A settlement will be reached between the steel companies and the union, we can look forward to increased demand for petroleum products in 1960, which should enable us to produce slightly more oil next year. Offsetting that ray of light is the continuing tendency to adjust posted crude prices downward to offset refining and marketing losses. These cuts in crude prices don't solve anything; they merely serve to lower the profit of the producing branch of the business, and consequently there is a lesser amount of money available for exploration and development wells.

Considerable progress has been made by the drilling and production people in cutting costs, and wider spacing of wells is making effective progress. I would look for about the same number of wells to be drilled in 1960 as in 1959. By the law of averages, we're due to find a large field (where I can't say) and this could cause a spurt in the drilling end of our business. If this did happen, the drilling contractors would have a very difficult time, due to the fact that a large number of skilled workers have left the oil fields and it would be difficult to lure them back.

Anyway, in about 1963 our business should definitely improve. In the meantime we'll have to worry along with overcapacity in every phase of our petroleum industry for quite some time. I hope I'm proved wrong, and I don't like being a gloomy Gus.

OUTLOOK: TOO MUCH IS BETTER THAN TOO LITTLE WARNS ONE PRODUCER.

Statesmanship Needed to Handle Supply

M. H. Robineau
President
Frontier Refining Company

IN 1960 I EXPECT a normal amount of new discoveries therefore current surplus of potential crude production over market will continue in our territory, which covers the east side of the Rockies and adjoining plains area.

Refinery runs in this region have been, and I believe, will continue, more nearly in balance with demand than has been the case in the Mid-Continent and on the Gulf.

Demand should show normal increase; enough to soak up any real substantial part of surplus capacity, at either producing or refining levels, both domestic and foreign.

Oversupply and resulting ruthless competition in many areas is our main trouble. The only chance to correct the situation is for top management of all companies to exercise industry statesmanship, consistent with their companies' best interests, by controlling production and refinery runs at their own reasonable market demands, and by ordering their marketing departments to be competitive but not destructive in marketing practices.

Mandatory Import Program Helps

W. M. Vaughey
Vaughey & Vaughey
Jackson, Mississippi

AT THIS TIME of re-appraisal, I find it difficult to reconcile my thinking with those who despair or are pessimistic in their outlook for the future.

For an industry little less than twice as old as I am, I never cease to be impressed with its accomplishments. No single industry in 100 years of seeking maturity has benefited mankind to a greater degree. To the political demagogues and the petty detractors the petroleum industry has a ready answer. It is written in the record.

Excessive imports of foreign oil over a period of many years undermined the price that domestic crude should command, and as a result prices for crude are still badly depressed. On the brighter side, these abuses were responsible for bringing about a mandatory import program. Because it has received excellent administration it has done much to stabilize conditions. Although never thought to be a cure-all, certainly it has brought about marked improvement.

Building excessive refining capacity resulted in excessive refinery runs. This was a natural development, but, nevertheless, imprudent. Again, the result of these abuses was depressed product prices. If we lay claim to maturing as an industry, then the errors of the past year should not be repeated in 1960 and the years ahead.

Admitting that some of our industry problems have been the result of a world wide oversupply of oil, this should not be regarded as a catastrophe, but instead, another economic problem that must be met. Too much is better than too little. For national security as well as our general economy, which would include our petroleum economy, it is imperative that equity between foreign petroleum and domestic petroleum be preserved. The ever-increasing demand for petroleum, both domestic and foreign, offers an encouraging picture for a long range projection.

The domestic industry for several previous years has been drilling more development wells than are needed to recover the same amount of oil that could be extracted if we subscribed to a larger spacing pattern for field wells.

For reasons familiar to all engaged in the industry, the above circumstances are particularly true since drilling and completion costs, primarily increased cost of labor and materials, continue to steadily climb. The IPAA current Cost Study Committee report shows that costs have increased 74.3 percent between the 1947-49 base period and 1958. Average posted price of crude oil meanwhile was only 18 percent higher in September of this year than it was in 1949 ($3.01 vs $2.55).

Inventory Reduction Chief Obstacle

J. R. Parten
President
Woodley Petroleum Co.

SO FAR AS this company is concerned, 1959 operations have been quite satisfactory, when viewed in the light of the conditions prevailing generally in the industry. The 1960 potential depends upon finding solutions to the problems which confront us. Domestic demand for oil products next year should be up about 4 percent as was the case this year. Foreign demand will, of course, be up substantially more than that. This is the bright star in the picture.

The principal problem that confronts the industry is reduction of inventory of refined products. Too much crude is being run by refineries. The solution of this will require industry statesmanship of the highest order. Other problems of maior importance concern governmental relations, for example the control of gas prices at the wellhead.

Federal Encroachment Serious Problem

Wallace C. Thompson, President, General Crude Oil Company

IT IS DIFFICULT to see any substantial improvement in domestic production in 1960 over 1959. While there may be an increase of a few allowable producing days in Texas, it is anticipated that world-wide supplies will continue to exert pressure on domestic operations during the foreseeable future.

By far the most serious problem facing our industry at this time, in my opinion, is the encroachment of the Federal government in all phases of our operations. We are particularly concerned with the regulation of natural gas producers by the Federal Power Commission and the attacks on depletion. It seems to be politically expedient to attack the oil business and we are constantly called upon to defend the basic principles on which our industry is founded.

This is a complex industry and it is almost impossible to reduce the many facets of depletion and the numerous problems of the natural gas producers to a level that can be readily understood by the general public. Based on the general line of attack used by most politicians it is obvious that they also do not understand the basic factors involved. However, it appears that our only hope to correct this condition is to vigorously defend our position and hope that the leaders in government will base their actions on a careful analysis of facts.

Good Wells Make Good News

A Report On Acid Treatments Engineered With the "Acid Guide"

January, 1960

The "Acid Guide"*—developed by Dowell—is the newest aid to the systematic engineering of acid treatments. Early results have been extremely successful, as these four examples show.

- **Stafford County, Kansas** (New Oil Well) This well was completed into the K, J and H zones of the Kansas City Lansing formation. There was no production before treatment. The object was to get an optimum production increase from each zone. Dowell engineers, with the aid of the "Acid Guide," recommended a five-stage treatment. The first two stages were wash treatments using BDA* (Breakdown Acid). Well was swabbed after each stage to remove as much mud as possible. Then each of the three zones was treated separately with Retarded Acid. Straddle packers were used to isolate zones. After clean-up, well tested a satisfactory 37½ boph.

- **Kingfisher County, Oklahoma** (New Oil Well) Completion was through two sets of perforations into the Oswego lime from 6257 to 6262 feet and from 6279 to 6282 feet. Production was increased from a show to 2 boph after 500 gallons BDA (Breakdown Acid). Standard treatment for wells in this field has been 10,000 gallons regular acid. Dowell used the "Acid Guide" and recommended injecting only 1500 gallons Retarded Acid at 5 bpm. Production increased to 7 boph—as good or better than earlier treatments. Operator saved $1350 in acid costs alone.

- **Archer County, North Texas** (New Oil Well) Pay was the fast-reacting Caddo lime. Completion was through perforations from 5200 to 5230 feet. Production was only a show. The "Acid Guide" indicated that the optimum treatment would be 5000 gallons Retarded Acid (acid-oil emulsion type) injected at 6 bpm. After clean-up following treatment, well tested 18 boph, flowing, on a 20/64 inch choke.

- **Western Alberta, Canada** (New Gas Well) This well was completed into the slow-reacting Wabanum formation. Perforations were from 11,042 to 11,094 feet. Production before treatment tested 5.8 mmcfd open flow. Acid treatment was engineered using the "Acid Guide." 10,000 gallons Dowell acid (with silicate control and surface-tension-reducing agents added) were injected down tubing at 7 bpm. After treatment, the well tested 33.5 mmcfd, open flow—more than a 500 per cent increase!

Whether you want lower treatment costs or greater stimulation, it will pay you to investigate the "Acid Guide." For service or detailed information, contact the Dowell office or station nearest you. There are more than 150 locations in the United States, Canada, Venezuela and Argentina. Dowell, Tulsa 1, Oklahoma.

*DOWELL SERVICE MARK

Services for the oil industry DOWELL

DIVISION OF THE DOW CHEMICAL COMPANY

Better Than a Year Ago

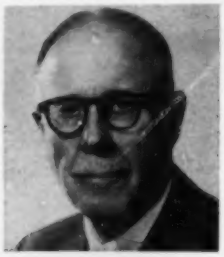
Robert L. Wood
Owner
Basin Drilling Company

OPERATING PRIMARILY in the Permian Basin of West Texas and New Mexico, I cannot see that our allowable production in 1960 will be much in excess of what it has been the past two years. If this should be the case, our operations will probably have to be restricted some 25 percent further due to increasing costs and lack of increased allowables.

Our chief problems in 1960 will be those problems which have existed during the previous two years. I am very much encouraged by the Mandatory Import Control Program and feel, if this program is allowed to continue as it is presently set up (with those few minor exceptions that might have to be made one way or another), that the next 18 to 24 months will see the domestic producing industry in a much healthier and more vigorous condition.

I am certainly much more encouraged at this time than I was a year ago and I hope that in 1960 we will find our industry in a much more optimistic state. I think this could certainly be the situation if domestic producers, refiners and foreign importers each will exercise the statesmanship so necessary to bring about this condition.

Research Expenditures at New High



Frank O. Prior
Chairman
Standard Oil Co. (Indiana)

HERE'S HOW the oil industry looks this year:

.... Demand for domestic crude oil in 1959 will total about 5.6 percent higher than in 1958. Product demand will be about 4.9 percent over 1958.

.... Products stocks have been excessively high, and as a result prices have been weak. However, recently refinery runs have been cut back somewhat. Also, prorated oil production in Texas, the largest producing state, has been held to a low level of nine days a month for the past five months.

Domestic sales of refined products alone are estimated to pass the $25 billion level for 1959, a new high. The year's research expenditures — a key to future growth — will increase to about $300 million, a new record.

Aggravating the domestic oil industry's economic problems are problems created by government — principally excessive gasoline taxes (amounting to more than $5 billion in 1959), and stifling regulations and controls. Federal regulation has held natural gas prices so low that it is affecting the level of exploration for oil and gas.

World-wide ability to produce crude oil is well in excess of demand. The domestic refining capacity has been somewhat overexpanded.

In the first six months of 1960 we anticipate an increase in domestic demand for petroleum products of about 3.7 percent over 1959's first half. Demand for domestic crude should rise about 4.2 percent, assuming no marked change in government control of oil imports.

Capital expenditures for 1960 will be about the same as the 1959 estimated domestic outlay of $5.2 billion. Importantly, such expenditures for manufacturing will be for modernization rather than for capacity increases. It is significant that foreign expenditures in 1958 for the first time just topped the total for domestic expenditures. It appears this trend is continuing in 1959 and will continue in the near future.

In the longer future, large increases in the demand for energy are expected, so the industry outlook is bright.

Must Create New Uses for Products

K. S. Adams
Chairman
Phillips Petroleum Company

U. S. BUSINESS in general should take an upturn in the first half of 1960 as the effects of the shutdown in steel output are erased. This may be followed by a levelling out of business activity in the last half of the year.

The petroleum industry will feel the beneficial impact of better 1960 business conditions. Rising domestic petroleum demand and declining exports will result in a total U. S. demand increase of about 4 percent over 1959. With import controls maintained, U. S. crude production can be expected to increase between 5 percent and 6 percent to meet indicated demands.

There are growing signs of better supply-demand balance, but it appears that the problems of surplus crude and products experienced in 1959 will be carried over into 1960. This points up a major need of our industry — a high degree of management statesmanship to keep crude runs and product inventories in balance with demand.

The entire industry also needs to create additional petroleum demand by outcompeting other fuels in customer appeal and quality, stimulating present uses, and creating new uses for its raw materials and products.

Calls Writers and Editors to Task

H. C. Jones
Carter-Jones Drilling Co.
President TIPRO

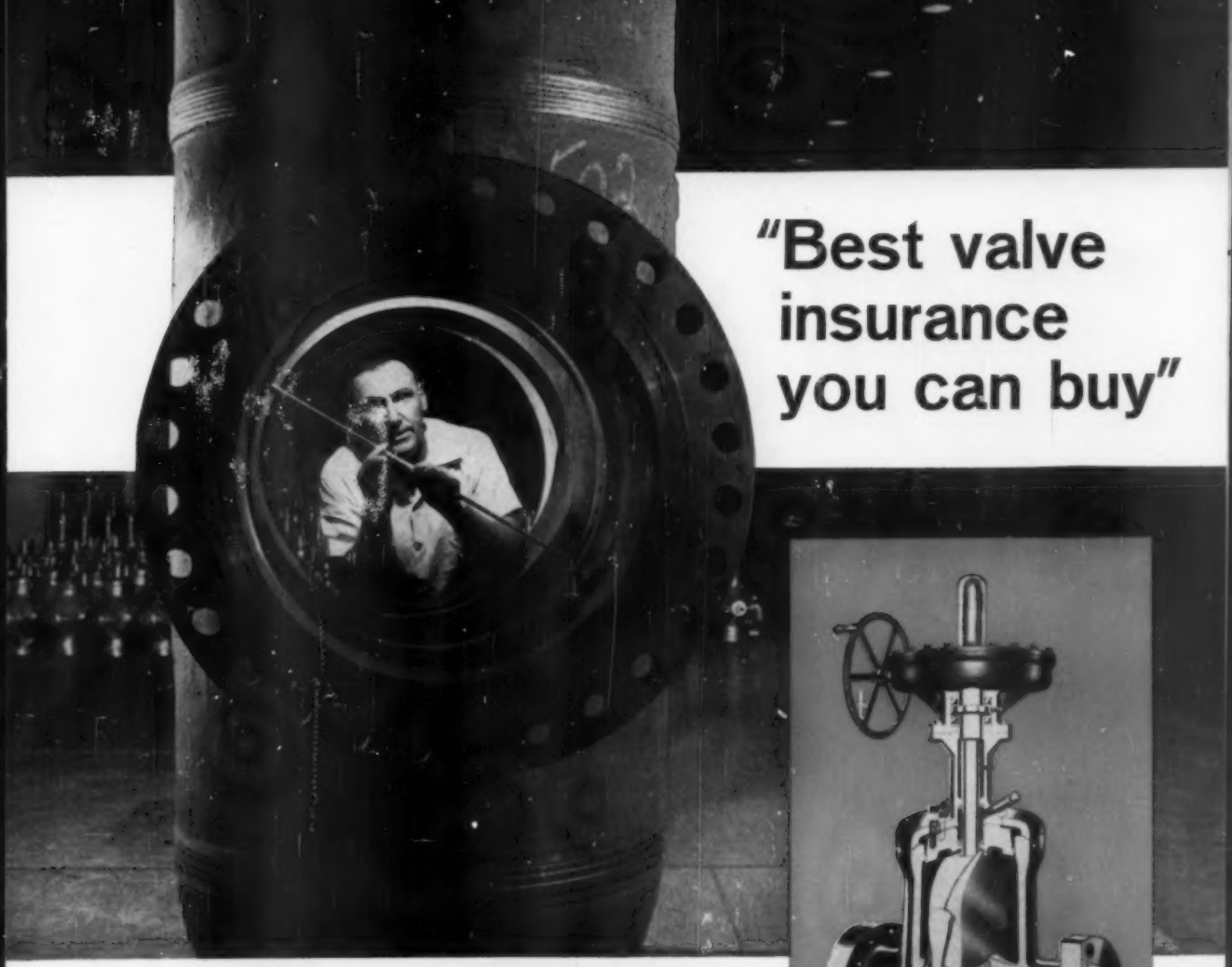
DOMESTIC PRODUCTION did well considering the bad atmosphere early in 1959. The year 1960 should see a gradual increase in production as domestic producers fight for their fair share of the market.

Refinery runs should remain about the same as stocks of products are brought into balance. Consumption of petroleum products will increase. With market demand steadying, drilling should increase slightly in 1960, thus benefiting each American.

Foreign demand for American products will continue to decrease since our mode of living has priced us out of present world markets. There will be constantly increasing pressure to bring in so-called low cost products from abroad. Under this strain, can we hold our place and bring the world up to our level or will we be pulled down to the world level?

Imports are the number one problem. Domestic petroleum, carrying the burden of a high standard of living, plus furnishing the hidden governmental subsidies that makes foreign oil possible at its present price, cannot compete without an equalizing tariff or some mandatory program. I

Continued on Page E-1



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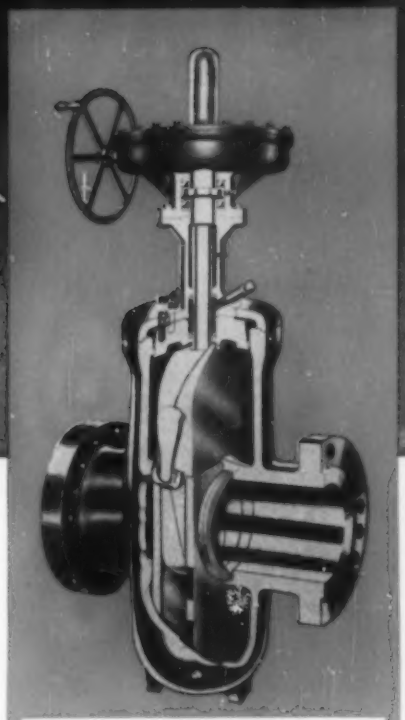

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Valves for the Petroleum Industry

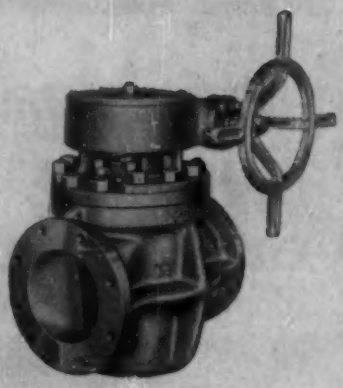

Fig. 3059G—300-Pound Steel Lubricated Plug Valve. Bolted gland type, gear operated. Sizes 6" to 12".

Fig. 2467—Small 300-Pound Stainless Steel O.S. & Y. Gate Valve.

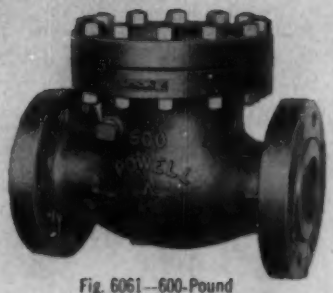

Fig. 6061—600-Pound Steel Swing Check Valve.

Fig. 2201—175-Pound W.O.G. Semi-Steel Lubricated Plug Valve. Single gland type.

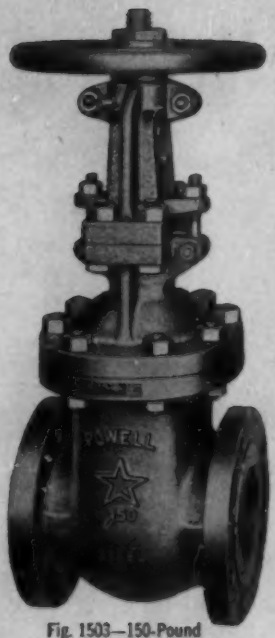

Fig. 1503—150-Pound Steel O.S.&Y. Gate Valve.

Fig. 375—Bronze Gate Valve for 200 pound W.S.P. Union bonnet, inside screw rising stem.

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THE CONFERENCE TABLE

With how little wisdom the world is governed. — OXENSTIERN

New Uses for Products Will Be Our Greatest Challenge

EDITOR'S NOTE: *This comment by Mr. Supplee was received too late for the Outlook article, Page A-8, but it is part of the 1960 preview.*

Henderson Supplee, Jr.
President
Atlantic Refining Company

IN VIEW OF the anticipated strong economic recovery following the 1959 steel strike, we expect U.S. domestic petroleum demand to average 9,820,000 bbl a day in 1960, 3.9 percent more than our current estimate of 1959 demand. Among the major products, distillate fuels should show the strongest growth to increase 4.7 percent. Much of the strength in distillates should come from higher requirements for railway and highway diesel fuels, demand for which was depressed as freight traffic fell during the steel strike.

Gasoline consumption may increase some 3.6 percent. Demand for aviation gasoline will be lower than in 1959, but highway use of gasoline should rise nearly 4 percent. With rising industrial and electric-power output, consumption of residual fuel oil could be considerably greater than in 1959. Limited supplies, however, may hold consumption of residual fuel near to the current year's level. Strongest growth will be found among the minor products, particularly aviation turbine fuels and liquefied petroleum gases.

Declining exports will hold total demand on the U. S. industry to a 3.5 percent gain. Supplies will need to be increased proportionately more than demand. Total supplies of new oils will need to rise 4.1 percent. Source of supplies will, of course, be influenced by the size of 1960 quotas for crude oil and product imports. If total imports average slightly more than 1,700,000 bbl a day, domestic production of 7,425,000 bbl a day of crude oil and 900,000 bbl a day of natural gas liquids will be required. These rates will be respectively 5.6 percent and 3.4 percent more than 1959 production. U. S. refineries may need to process crude oil at about an 8,355,000 bbl daily rate versus the average throughput of 7,984,000 bbl a day this year.

We expect "free foreign" petroleum demand to rise some 8 percent next year. Once again, Europe and the Far East should show the strongest growth.

Despite higher levels of demand, excess capacity of U. S. flag tankers may be little, if any, less than in the 1959 period. Excesses in the foreign flag fleet will be somewhat larger than in the recent past.

The major oil industry problems of 1960 promise to be those of surplus capacity, import controls and markets. None will be solved completely in the coming year, but the industry should move in the direction of solving each of them.

In the Korean War years and thereafter, the oil industries built refineries in excess of immediate requirements in anticipation of continued demand growth at post World War II rates. When demand did not develop as rapidly as expected, excess capacity led to over-production of oil products and weak product prices.

Recently, building rates have slowed to nearly nothing, and the demand trend has turned upward again after marking time in 1957 and 1958. In 1960, refineries, on average, should operate at about 85 percent of capacity. The danger of over-supply will continue; but with operations nearer to capacity and with increasing industry awareness of the market implications of excessive runs, there is some hope that supplies will be geared more closely to requirements.

Crude producing capacity is greatly excessive by market standards. Import controls now make state regulation more effective, but lack of uniform controls from state to state continues to present problems.

Import controls have not yet been an effective device to strengthen domestic oil markets since it has taken time to work off earlier stock excesses. If winter demand is reasonably strong, however, the effect of import limitations may become apparent early in 1960. Indeed, it may become apparent that controls will need to be modified to provide equitable treatment of East Coast refiners, markets and consumers. Especial consideration may need to be given during 1960 to allocations of imports of residual fuels and specialty crudes.

By any measure, the *rate* of growth of petroleum demand has slowed though future annual *volumetric* increases in consumption will continue to be at least as great as in recent years.

To assure its continued strength, the oil industry must now find and promote new uses for its products and compete more vigorously with other fuels for existing markets. This perhaps, is our most challenging problem, not only in 1960 but in the longer run.

High aims form high characters, and great objects bring out great minds . . . — Tryon Edwards

Clip Out and Check

The table below is the result of sticking out our neck. Few companies are willing or able to divide by branches of the industry and also by foreign and domestic operations. Here's the result of our analysis for 1960.

ESTIMATED CAPITAL EXPENDITURES BY U. S. INDUSTRY IN 1960

	U. S.	Abroad	Total	%
Drilling and Production	$3,600 million	$1,245 million	$4,845 million	64.6
Manufacturing (Also Petrochemicals)	930 "	320 "	1,250 "	16.7
Transportation (Not Gas Transmission)	340 "	80 "	420 "	5.6
Marketing	660 "	150 "	810 "	10.8
Other	190 "	70 "	170 "	2.3
TOTAL	$5,630 million	$1,865 million	$7,495 million	100.0

For other estimates see page A-8

Jobs Ahead

This month we embark on a new decade with priceless possibilities.

We must invent and supply energy for space travel.

We must find new uses for our products.

We must have huge supplies on tap without letting them unbalance our economy.

We must show struggling and unstable countries that only a nation's integrity can give it solid footing.

We must cut costs — by automation, by other efficiencies, by nurturing a regard for costs.

We must plan ahead and keep plans in tune with events.

We must work through political programs to inform employees and others about oil and gas legislation.

We must keep a weather eye out for inflation, taxes, our national welfare.

$600 Million a Day!

Congress authorized new Federal spending at the rate of something over $600 million each day of the last session. Congress provided new Federal spending authority for the current (1960) fiscal year, plus "supplementals" for the previous fiscal year, totaling more than $85 billion.

Management Letter Has Special Ideas

Prentice-Hall, Inc., Englewood Cliffs, New Jersey, this year began what they call "The Prentice-Hall Management Letter" which is issued bi-weekly for $30 a year. Its purpose is to "spur sales . . . trim costs . . . boost profits." There is much good material in the letter, the main objection being that it is spread very widely. On the other hand, that is perhaps one reason it keeps such timely coverage on new management ideas. Examples of articles are "How Closed Circuit TV Can Cut Your Operating Costs," "Tax Free Salary Increase," "Hints for Successful Interviewing," with an interviewers' checklist. Occasionally special supplements are included such as the "Checklist of Sources of Ideas for New Products and Services." This is probably worth a trial run to see if it gives you enough ideas.

✔ *Good company, and good discourse are the very sinews of virtue.* — Izaak Walton

Report on Scientific Manpower

Federal officials and others concerned with the needs of the Federal Government as the nation's No. 1 employer of engineers and scientists attended a conference on scientific manpower in Washington recently. Here are the key points brought out by speakers who numbered top scientists in the country:

1. Competition for scarce top-quality scientific personnel can be expected to continue and possibly to be intensified in the foreseeable future.

2. It is unlikely that Government compensation for scientists and engineers can be made fully competitive with pay offered by industry, but the gap can in large part be offset by other attractions which only the Federal service can offer.

3. Government's career scientific service must be flexible enough to allow for advancement to top rungs for scientists who wish to stay in creative work rather than transfer to administrative duties.

4. Government must recognize that scientists have different interests and motivation which require special consideration, and agencies must fashion attractions that interest them.

5. The popular image of the scientist must be improved.

6. Undue reliance on outside laboratories for new work of large scientific interest could greatly impair the morale of Government scientists and vitality of needed public facilities.

The pros in favor of government service may interest those in private companies who employ scientists and engineers. Superior attractions in government service were listed as:

1. Do research on a wide variety of exciting and challenging programs.
2. Engage in basic research without production-related pressures.
3. Work in the most modern and fully equipped facilities without worry about the adequacy of research funds.
4. Participate in pioneering work in new areas of science and technology.
5. Publish research results without fear of compromising the employer's competitive position.
6. Gain public recognition of professional achievements.
7. Participate in work vitally important to our national security and progress.

Dr. Guy Suits, vice president and director of research, General Electric, added other employment advantages of the federal scientist. He said they include: "The opportunity to take a longer range, more scientific approach to his work than is allowed to any but a select few industries; variety and wide distribution of work; availability of laboratory equipment of a size few industrial firms could afford; and activities tied more directly to national objectives that aim at important benefits for all the people."

Dr. A. B. Kinze, vice president of research, Union Carbide, discussed the vital role research plays in our entire economy. He said: "Of some $33 billion a year spent in this country as investment capital, about a third, or around $11 billion, is being channeled into research."

✔ *Education is the cheap defense of nations . . .* — Burke

Four Steps to Level

Four steps to save American industry from a losing fight against foreign competition were suggested by Samuel Lenher, a vice president, director, and the adviser on research for the Du Pont Company. Warning that foreign companies have demonstrated their ability to "match our best efforts" and now have a competitive edge because of wage rates which are only a fraction of those in this country, Mr. Lenher called for:

1. A tax structure to encourage industrial growth and expansion.
2. National policies to encourage the modernization of industrial plants and increase their efficiency.
3. Strengthening of the patent system.
4. Tariffs applied selectively to place foreign-made products on an even footing with United States goods.

In an interview for "Better Living," a company magazine, Mr. Lenher said undercutting of domestic producers would threaten the defense potential of the United States, restrict its scientific progress, and reduce job opportunities for American workers. He cautioned against assumptions of American superiority in technology, and declared the foreign challenge would not be defeated "by throwing a few more scientists into the battle."

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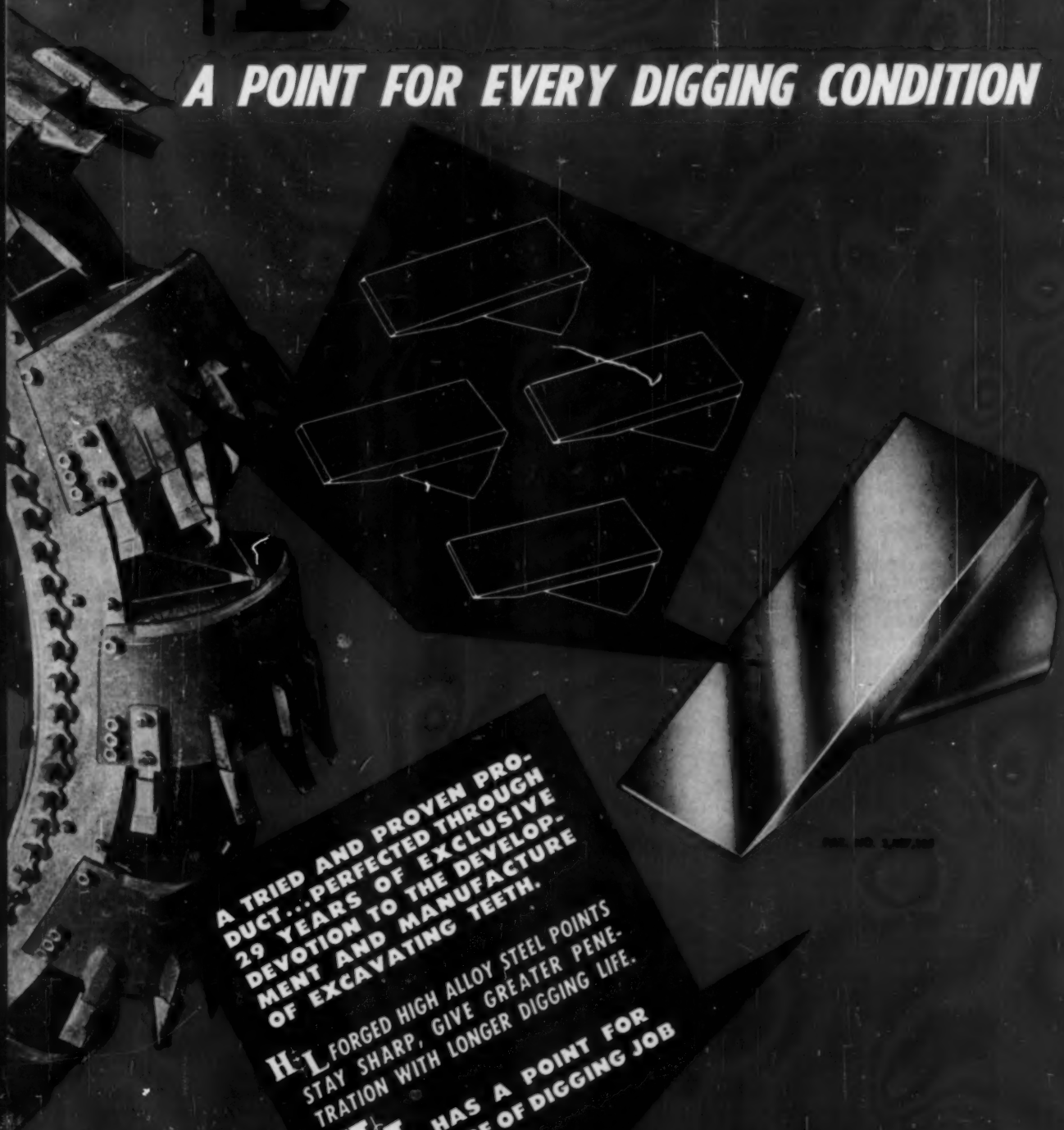

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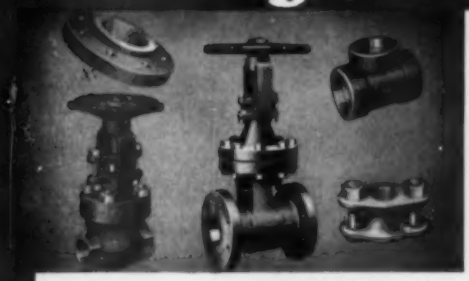

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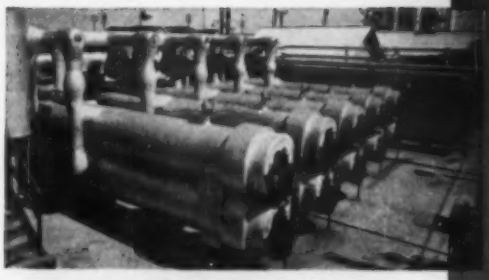

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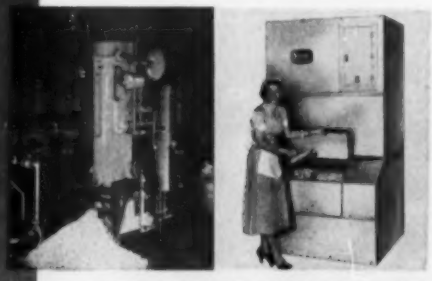

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OUTLOOK: STRIKE WEAPON IS BAD FAIRY AT BIRTH OF ECONOMIC BOOM.

Continued from Page A-16

believe the present program will stand and this situation will ease.

Next problem is federal control of natural gas pricing. After five years of price fixing, what good has the FPC done for gas either producer-wise or consumer-wise? I believe this congress will awaken to its responsibility and remove this thorn from the side of government and industry. Production costs will swing to normal, profiting the producer and resulting in savings to the consumer.

Another thing we suffer from is an atmosphere contaminated by a constant flow of half truths and innuendos. How can the man on main street know the truth? I do not believe that it is the desire of the American public that a great natural resource cease to be developed and produced.

Writers and editors must assume the responsibility of their positions and clear the smog of doubt and distrust.

Strikes Will Dislocate Oil Operations

E. L. Steiniger
President
Sinclair Oil Corp.

POSSIBILITY OF SERIOUS strikes in steel, rail and other industries or services, which would dislocate and hamper the orderly manufacture of and subsequent transportation of products, is one problem we may face in 1960.

Another is extraordinary build-up of inventories by all manufacturers either in anticipation of strikes or going beyond a make-up of the recent steel strike. This would cause very uneven demand throughout the year.

I believe both items will be anticipated in time to soften the potential impact and that from a petroleum viewpoint we will be able to handle our business in a fairly satisfactory manner.

Tie Operations to Seasonal Changes

J. C. Donnell II
President
The Ohio Oil Company

ON THE ASSUMPTION that the steel strike is not resumed, the nation's economy should be buoyed by a high and rising rate of industrial activity during at least the first half of 1960. This should prove stimulating to the demand for petroleum. With above-ground inventories apparently being brought into better balance and in view of the continued control of imports, the petroleum industry may expect increases in its domestic operations.

We estimate that domestic crude oil production should increase between 4 and 5 percent, and that runs to stills may be up between 3 and 4 percent. We believe, however, that these operations must show a closer relationship to the seasonal changes in demand for petroleum if the industry is to maintain a semblance of stability.

In addition to the problem of adjusting to seasonal changes in demand, the petroleum industry will be confronted in 1960 with a forceful attempt to eliminate or reduce the percentage depletion provision in the nation's tax laws. We believe that the industry must make a major effort to educate both our legislators and the people on the consequences of any such action. If this educational effort is properly directed, then we may reasonably expect the Congress once again to recognize the essentiality of percentage depletion to the nation's welfare and safety.

It is also imperative that the entire petroleum industry continue in 1960 to press for remedial legislation in connection with Federal regulation of natural gas prices at the wellhead. These efforts should be continued even though the political situation in 1960 seems to preclude success during the next year. Any interruption to these efforts will only serve to delay the correction of the untenable situation in which natural gas regulation has been permitted to develop.

Oversupply Has 5 Years to Go

W. H. Helmerich, III
Executive Vice President
Helmerich & Payne, Inc.

OUR COMPANY IS only concerned with the crude oil end of the business but, of course, we closely observe the other integrated operations because of their influence on our company. We think that 1959 over-all represented a strong recovery from the 1958 decline and that 1960 should continue this trend, although not perhaps by the same percentage increase. So far as we can see this is an across-the-board improvement, with strong showing to about the same extent in each area. Specifically as far as the increase in demand for 1960 is concerned, our hunch is that we should again see a domestic plus margin of 4-5 percent.

We see one long range problem which dominates all others for years to come. This is the classical economic problem of oversupply. In our industry it means excess crude oil stocks will put pressure on all price levels in the industry, particularly on those prices closest to the wellhead. There can be no short range solution to this problem; in the long run demand may grow to equate supply. This oversupply, we think, will last at least five years.

Texas Operators Are Hunting

Robert J. Bradley
Chairman
Producing Properties, Inc.

GETTING DOWN TO specific cases, I think we'll probably average 10 producing days a month in Texas. Operators in the state will lose more of their share of the nation's oil production. It's down to about 38 percent of the total now and it can go lower.

It looks like crude price structure in California will hold and I hope it does in the Mid-Continent and Gulf Coast.

For our fiscal year ending August 31 our earnings were up 136 percent — highest in our five years of operation. We expect 1960 to be better for us and somewhat better across the board for most producing companies. Unless, and until, the major refining units schedule their output in a more realistic and sensible manner, we cannot look forward to real stability in the domestic industry. ★ ★

HOW TO BE A MANAGER

Make Time to Prepare for a Bigger Job

Chalmer G. Kirkbride

"If you can fill the unforgiving minute with sixty seconds' worth of distance run, Yours is the earth and everything that's in it, And — what is more — you'll be a man my son!" — Rudyard Kipling

THESE FAMOUS LINES are well-known to almost every schoolboy; but while they still may be able to recall them verbatim in later years their real meaning may be lost — or was never really understood in the first place.

Time is unforgiving. It demands of us that we use it wisely if we wish to achieve success. So we have to learn to budget it. We have to evaluate those things to which we give our time, not only during working hours, but just as importantly during leisure hours, too.

Of course there are many requirements for success, but I believe that the most important by far is to have well-defined goals and objectives. Success is no accident. It doesn't just happen. Success is achieved only by those who first of all determine what they want in life, develop a well-defined plan to reach their objective, then quickly put the plan into action.

It necessarily follows, therefore, that success can be achieved only with positive attitudes. And the opposite is equally true: If a man doesn't have a goal in life, if he doesn't know where he is going, he will be subdued by negative attitudes. His thoughts become confused. Anxiety, worry, fear, frustration, and many other negative termites, begin to gnaw away at the very fiber of his being. They sap his energy. He becomes as he thinks — frustrated, confused, afraid and defeated. If a man is a negative thinker he becomes a negative person. If he thinks about nothing, he becomes nothing.

He will be subdued by negative attitudes.

Success comes to the man who takes control of his mind and thinks only in terms of what he wants to accomplish, how he intends to accomplish it, and then translates his thoughts into action. These are two essential ingredients for success — positive thinking followed by positive action. Both depend on the wise allotment of time.

If you would prepare for the bigger job ahead, you must take time to prepare yourself for advancement. You can't sit idly by and wait for the "breaks." The hardest men to find in any organization are young men who are not only eager to assume greater responsibility, but who are willing to pay the price in time and effort today to reap tomorrow's

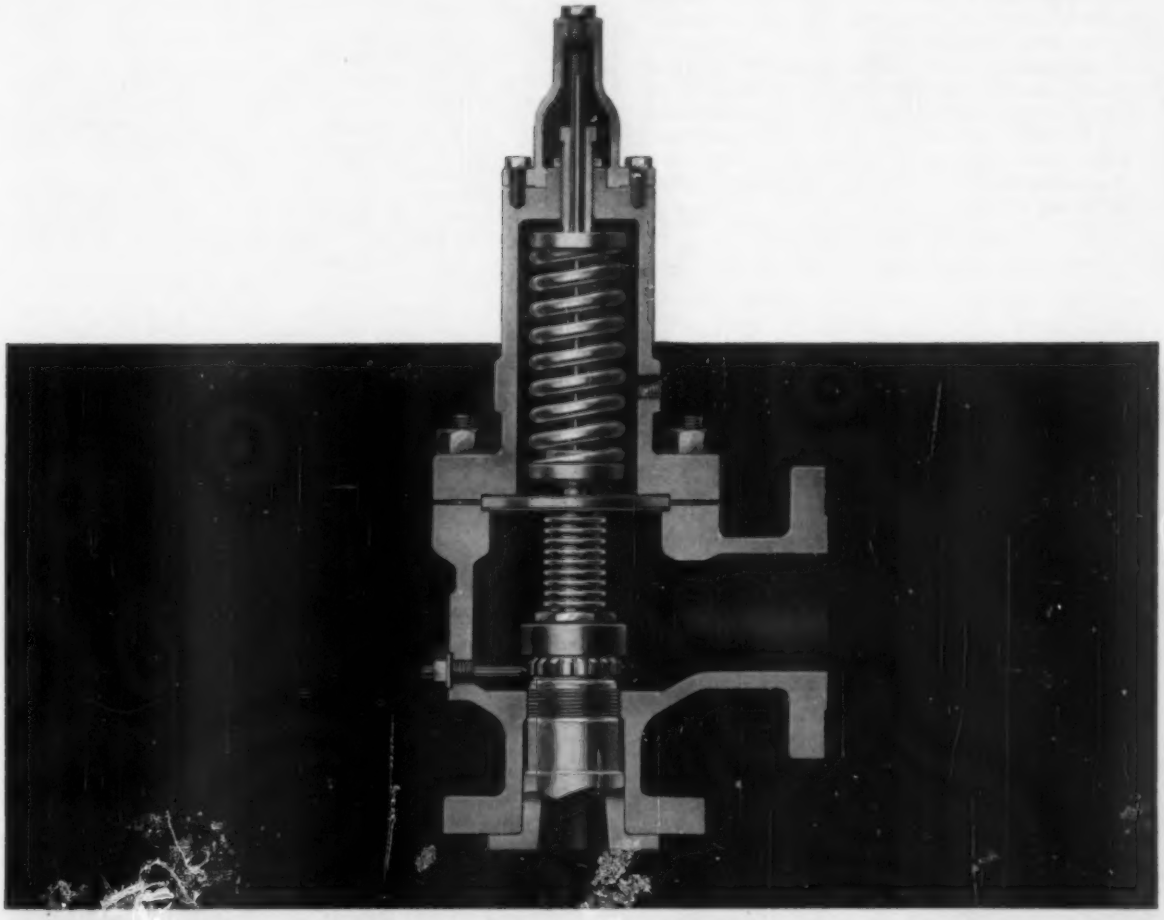
You can't sit idly by and wait for the "breaks."

Chalmer G. Kirkbride, *executive director of Sun Oil Company's Research and Engineering Department is also president of AviSun Corporation, an equally-owned affiliate of American Viscose and Sun, engaged in the manufacture of polypropylene resins. He joined Sun in 1956 after serving as the president and chairman of the Houdry Process Corporation.*

He graduated from the University of Michigan with a bachelor of science and master of science degrees in chemical engineering in 1930 and began his career in engineering with the research department of Standard Oil Company (Indiana). In 1934 he left that company to become assistant Director of Research for Pan American Refining. In 1942 he joined Magnolia Petroleum as chief of chemical engineering development.

From 1944 to 1947, he served as Distinguished Professor in Chemical Engineering at the A&M College of Texas. A text book, "Chemical Engineering Fundamentals" which he compiled from the subject matter of his basic course has been adopted by many leading engineering schools. Mr. Kirkbride left Texas A&M to become manager of Research and Development at Houdry laboratories in Linwood, Pennsylvania. A year later, he was named vice president in charge of the division and a director, and in 1952 was appointed president and chairman. He is currently a Houdry director.

Look into Lonergan Bellows Valves



Seven exclusive features reduce maintenance costs; provide increased valve versatility.

Like all bellows valves, Lonergan valves are designed to keep corrosive or viscous fluids away from working parts. In addition, they provide a balancing action against a variable back pressure. The similarity between Lonergan and any other bellows valve ends there. *Only Lonergan valves provide:*

1. *Saf-T-Alarm to warn of bellows failure. Alarm may be remotely located. (Optional at extra cost.)

2. Complete interchangeability with conventional valves of the same series.

3. Versatile cap arrangement. Bolted cap is standard and is interchangeable with a packed cap without taking the valve off the line or out of service. Gag facility is included.

4. *Simplified nozzle replacement due to an exclusive knock-out feature. (Optional.)

5. A Hydro model; a patented, true, non-chattering liquid valve. Elimination of chatter ends bellows failure due to excessive flexing.

6. Reserve seating surface obtained from a built-in spare disc.

7. PVC trim, where pressure-temperature conditions permit.

These seven features mean economy for Lonergan valve users —in first cost; in operation; in maintenance. If your plant uses bellows valves, then it will pay you to investigate Lonergan. Series DB bellows valves are described in a new bulletin. Series D valves, available without the bellows, are also described. Write for your copy today.

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APPLY ANYWHERE

— the world is searching for such men.

successes. They set their goals. They prepare for tomorrow's opportunities. They make their own "breaks" because the "breaks" occur when preparedness and opportunity meet.

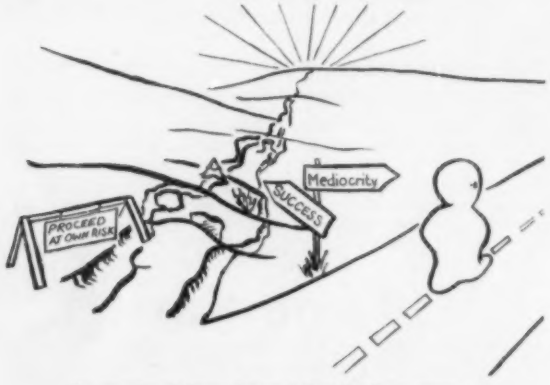
The great Irish sage, George Bernard Shaw, put it this way: "People are always blaming circumstances for what they are. I don't believe in circumstances. The people who get on in this world are the people who get up and look for the circumstances they want; and if they can't find them, make them."

Summed up, the price of success is self-development. This means taking time, or making time, to prepare for the bigger job ahead. Every man who claims he wants success should ask himself the question: Am I willing to endure the hardships that go with the struggle for rewards and recognition that come with achievement? Or shall I simply accept the apathetic and complacent contentment that goes with mediocrity?

Why is it that in this great Nation of ours, truly a land of opportunity, so many men who claim they desire success fail to achieve it?

Suppose we were to select 100 men of age 25 who are all starting out even in their business life, and all determined to succeed. Each expect: to be financially independent by the time he reaches age 65. Of the 65 still living at age 65, only five will be financially independent, five will still be working for their livelihood, and 54 will be dependent upon someone else for the bare necessities of life.

It is appalling to think that, of approximately 14 million people of 65 years of age or over in the United States today, one million still have to work and about 12 million are dependent upon someone else for their livelihood.



He wandered from the route that leads to success.

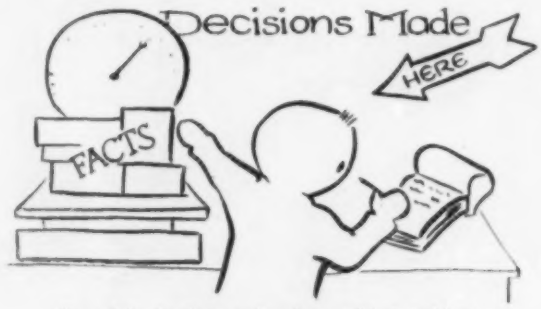
While financial independence is only one measure of reward of success why is it that in this land of abundance more than 90 percent of those reaching age 65 fail to become financially independent for the necessities of life?

Can we blame the jobs these men held or the men themselves for the fact that they failed to achieve success? Very likely the degree of success is a measure of the man himself. We will find that these men lost sight of their goals, wandered from the route that led to success, or simply stagnated. Time and effort were dissipated.

Have you ever noticed that the successful man continues to be successful; yet the man who is a failure continues to fail? It is because the successful man has specific well-defined goals, but the failure never had a definite objective. He never had the slightest idea of where he was going.

In addition to a specific goal, I can assure you that the successful man also put into practice a well-delineated plan to reach his objective and that a very large part of his plan was devoted to self-development.

It is easy to recognize the person who has successfully followed a plan of self-development. He is able to make decisions without procrastination. He weighs the facts and makes a decision with all the confidence in the world. He



He weighs the facts and makes confident decisions.

does not stampede when trouble is encountered; on the contrary, he tends to minimize rather than magnify trouble.

There are other attributes by which the successful man is readily recognized. These are personal qualities he has developed. Let's look at the more important ones.

Faith is an essential quality, inherent in positive thinking. There is no such thing as negative faith. Faith in yourself, or self-confidence is a prerequisite to success. If a man does not have confidence in himself, he can be certain that no one else will place confidence in him. A man who makes time for self-development to prepare for advancement must have supreme confidence that he will reach his destination. Furthermore, this faith must be so strong that there is not the slightest doubt in the minds of those with whom he comes in contact that he knows exactly what he is doing.

I recall a conversation from Shakespeare's Julius Caesar when Brutus and Cassius were planning a course of action. It was the night before their forces were to clash with those of Mark Anthony and Octavius Caesar. Cassius advised caution and suggested that they maintain their position in their entrenchments. Brutus advised a different course of action. In stirring and challenging words he said:

> "There is a tide in the affairs of men,
> Which, taken at the flood, leads on to fortune;
> Omitted, all the voyage of their life
> Is bound in shallows and in miseries.
> On such a full sea are we now afloat;
> And we must take the current when it serves,
> Or lose our ventures."

Another quality essential to success is integrity. The

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4130 alloy steel tube with alloy steel tip and socket.

403 stainless steel tube with alloy steel tip and socket.

403 stainless steel tube with 416 stainless tip and socket.

316 stainless steel tube with alloy steel tip and socket.

316 stainless steel tube with 303 stainless tip and socket.

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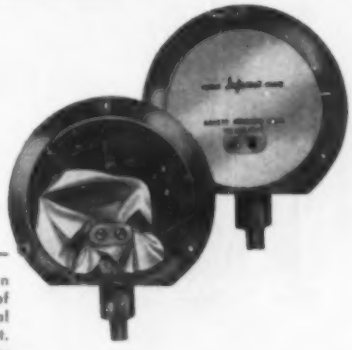


Explosive force merely opens safety back—

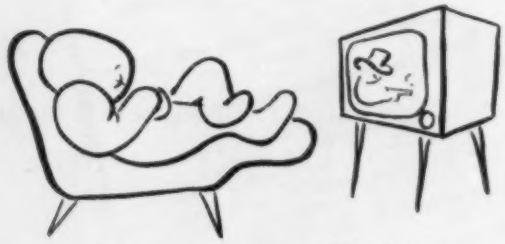
Photo shows result of laboratory test in which gun cartridge was discharged in rear compartment of Safecase. Thin, tough back yields to abnormal pressure, but cannot be dislodged by blowout. Front of gauge remains intact, protected by heavy metal barrier.

one quality that most often distinguishes the highly successful executive in his personal integrity.

Courage also is required. Anyone engaged in self-development will find himself tempted to direct his efforts toward shallow pleasures, away from his constructive program. People are too often inclined to do only what someone asks them to do. It takes courage to muster the initiative to set up a well-planned program of self-development, and courage to maintain strict self-discipline to carry the program through. No coward should attempt it.

Closely linked with courage is determination. This is a quality of character — a deep-rooted force that drives one on to the goal regardless of difficulties encountered. A person possessing this quality rarely starts anything he does not finish. He gets results.

Energy is an obvious prerequisite for success. Too many



Too many people are lazy and indolent.

people are lazy and indolent. Many persons of ability are willing to accept mediocrity because of sheer laziness. The man who prepares himself for the bigger job is the man who devotes more time to the job than those less energetic. Then, too, he thinks more about the job while away from it.

Initiative is an expression of energy. The man who wants to get ahead doesn't wait to be told about a job that should be done. He is continually on the watch for things that need doing and sees that they are done. He is a trail blazer. While the majority of people are in a rut, the man with initiative travels where there are no ruts. He looks for new and better ways of doing things. A master of the positive approach, he does not indulge in negativistic thinking.

Examine the records of men who have attained success. You will find that they possess these positive qualities. You will find also that, without exception, they have devoted much of their time and effort to self-development. Your success, too, will be determined largely by the development of a positive attitude and by the amount of time and effort you are willing to devote to self-development.

Douglas Lurton* said: "There is a broad general principle in life that we begin to achieve only when we begin to believe in the power that is within us and support our beliefs with positive thought and action. We begin to fail when we let negative attitudes prevail or drift into a negatively passive acceptance of the scraps that fall from the table of life."

If you are to prepare yourself for the bigger jobs, you must develop positive thoughts and carry through with positive action. This will include a well planned self-development program that will involve acquiring a knowledge of people as well as a knowledge of facts. If you make time to prepare for the bigger jobs ahead you will find your opportunities when these positions are being filled. Proper preparation can be accomplished by self-development. Are you willing to pay the price?

He is a trail blazer.

Give Yourself a Quiz

What would a successful manager do if:

1. faced with increasing amounts of administrative detail?
2. asked to explain a costly mistake?
3. reviewing two candidates for the same promotion?
4. confronted with "spare" time while making transportation connections?
5. concerned with reorgainzing a department's functions?
6. determined to increase personnel productivity?
7. asked to participate in a community service project?

What approach would you take to:

1. determine if a venture should be undertaken?
2. inattention to necessary details by employees?
3. an undercurrent of conversation while you addressed a staff meeting?
4. an employee who appears to becoming an alcoholic?
5. retain a valued scientist unhappy with his administrative responsibilities?
6. competitors seeking to "pirate" key men from your company?
7. expand hiring to supply permanent, qualified personnel?
8. uncover why a dependable person has suddenly become unreliable?

Read For Business Success

[1]*Allen, George Howard, ed., Individual Initiative in Business, Harvard University Press, 1950.*

[2]*Appley, Lawrence A., Management in Action; The Art of Getting Things Done Through People, American Management Association, 1956.*

[3]*Bower, Marvin, ed. The Development of Executive Leadership, Harvard University Press, 1949.*

[4]*Bursk, Edward C., ed. How to Increase Executive Effectiveness. Harvard University Press, 1953.*

[5]*. . . Human Relations for Management, Harper, 1956.*

[6]*Bursk, Edward C., and Dan H. Fenn, eds. Planning the Future Strategy of Your Business, McGraw-Hill, 1956.*

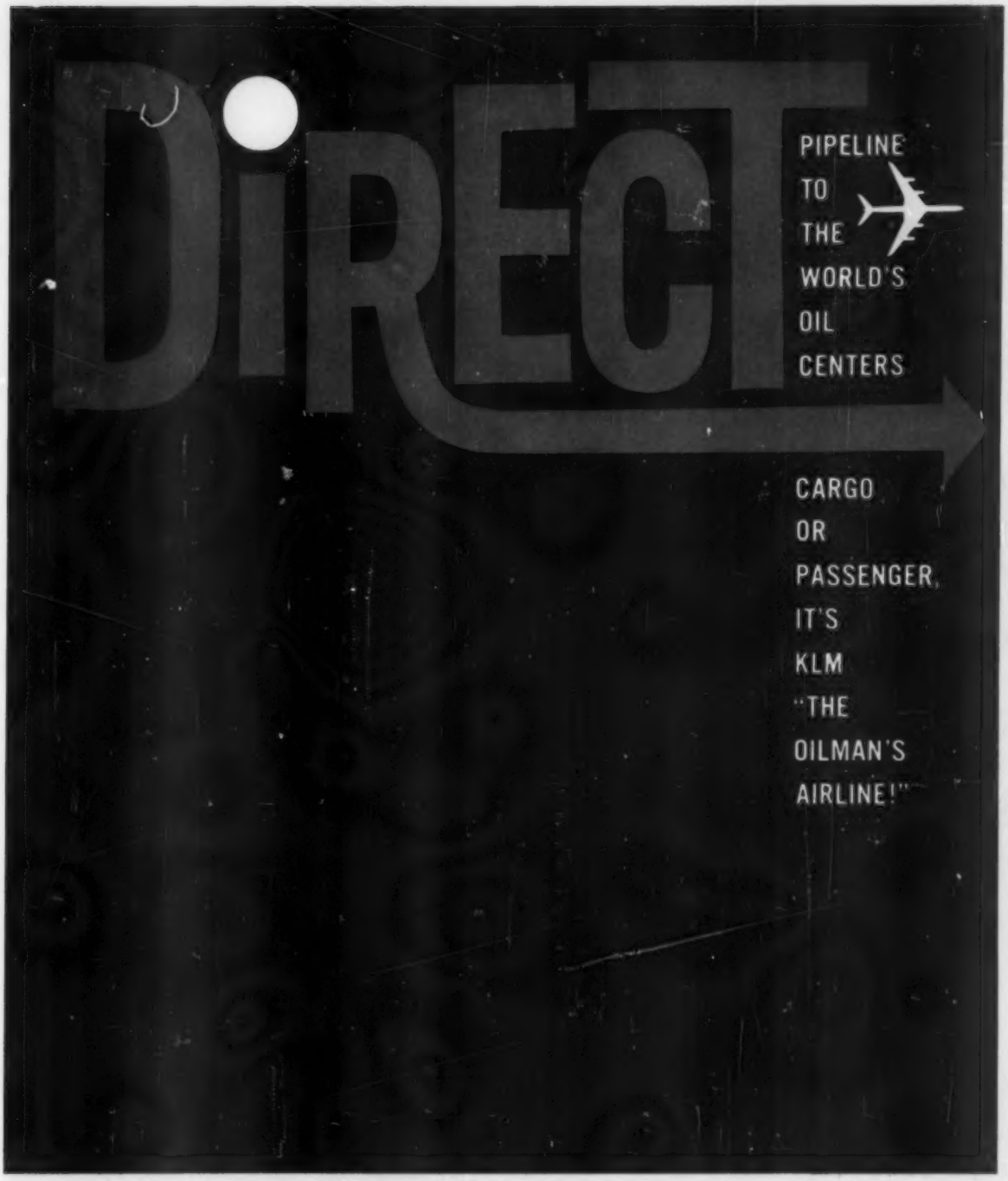
[7]*Given, William B., Bottom-Up Management, Harper, 1949.*

[8]*. . . Reaching Out in Management, Harper, 1953.*

[9]*Laird, Donald A., and Eleanor C. Laird, Practical Business Psychology, 2d ed., McGraw-Hill, 1955.*

[10]*Villanon, Luis J. A., ed., Management Men and Their Methods; 33 Case Studies in Executive Techniques, Funk & Wagnalls, (with Modern Industry Magazine) 1949.*

*"The Power of Positive Living", McGraw-Hill Book Company, New York, New York (1950).



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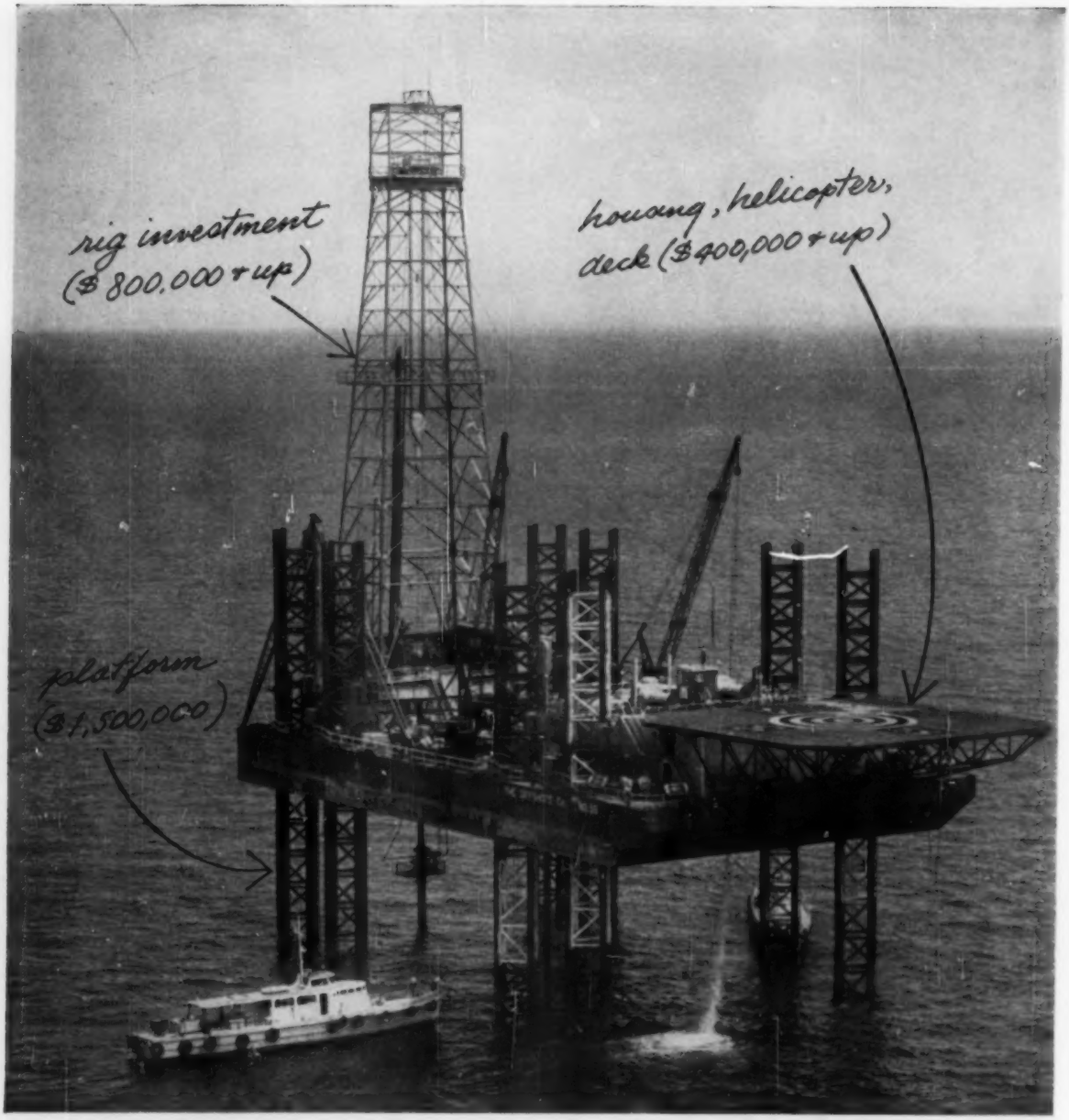
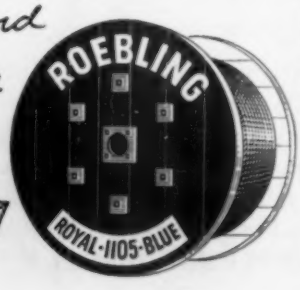


When you spend $4,000,000 for an offshore rig you can't afford not to use the best rope



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What Industry Expects of the Engineer

Management knows that growth of our enterprise economy depends upon an ever expanding program of research and development — which in turn depends upon the engineer and scientist. Industry expects technical competence from members of that professional elite — it also asks them for understanding of social and political forces and for bold leadership in reaching toward a more abundant life.

Marvin M. Schmidt

ARE THE AMERICAN engineers and scientists doing the best job of which they are capable? Is the quality of our scientific and engineering knowledge all it ought to be?

Management is properly asking these questions. It must depend heavily on the engineer and scientist. It must consider that much of the rising fixed costs of doing business is in research and development, a field virtually limited to engineers and scientists.

Industry, of course, expects technical competence from its engineers. To whatever extent, if any, America may now be lagging in such competence, by contrast with its economic competitors, that lag can and will be overcome without undue difficulty. The question here is only one of how much time will be needed to reassert unquestioned supremacy, and I believe it will be less than the pessimists fear.

But a growing part of industrial management—and, in my opinion, the most responsible and forward-looking part—has fears of a deeper sort about engineers, scientists, and members of the professions generally. We fear that the engineer, the physicist, the chemist may feel he has discharged his full debt to society by attaining utmost mastery of his own occupation.

There is a strong temptation for the professional man to feel this way, as he struggles to assimilate the mass of new knowledge constantly being introduced into his own specialty and to relate his work to even a few other disciplines that are most closely allied with it.

There is a strong temptation for the scientific and technical man to say to himself, "I have devised the formula — or put together the machine — and that is the end of my responsibility. What happens afterward, or what happens outside the world of formulas and machines is somebody else's responsibility."

There is, I suspect, a temptation for the technically educated man—trained in mathematical exactitude and the handling of nonhuman materials — to feel a secret scorn for what he understandably, but shortsightedly, views as the bunglings of politics and the untidy confusion of humanity outside science.

Human Problems in Industry

It may surprise some of you to learn that industrial management becomes more and more convinced that strictly technological problems of the kind with which you directly deal as engineers are now of secondary importance to the far less manageable human problems that crowd in upon industry from every side. Management is increasingly preoccupied with a concept called "freedom," which lies beyond the boundaries of mathematics and science but has a greater practical bearing on the future of American industry than the blueprints and designs and testing laboratories. Management is giving serious heed to words like those of Dr. Charles Malik, the great Lebanese philosopher and statesman, who said the other day at Dallas, Texas, that the United States faces three great dangers to its survival as a dominant force for good. Dr. Malik listed these dangers as follows:

1. **A possible weakening in America's faith in its own ultimate values.**
2. **A wave of complacency, ease, and comfort.**
3. **A conspiracy of forces, worldwide in nature, whose only concern is to blacken the name of America.**

Some will say that engineers and scientists are doing their full part to meet these dangers by providing America with the means of out-producing its enemies in material goods, whether of military hardware or of civilian well-being. Industrial management is no longer sure that this is a good enough answer; in fact, it holds the opinion that this is not enough.

At the recent Congress of American Industry, leading industrialists from all parts of the country heard Dr. Felix Morley, former President of Haverford College, tell them: "Very possibly desire for freedom is weakened, rather than strengthened, by the lavish satisfaction of stimulated physical wants. In any case," Morley emphasized, "productive capacity and technological skills do not of themselves spell freedom." What Morley told us in New York is underlined by our own reflections on the destruction of freedom in Nazi Germany and in the present Communist world, despite their endowment with a highly trained technical *elite*.

That excellent reporter, Ernest K. Lindley, has given us a case study of the emasculated role played by this *elite* in the present-day Soviet Union. Summarizing his first-hand observations in *Newsweek* magazine, Lindley wrote:

> "Much of the Soviet *elite* class has been neutralized politically. This is the class-engineers, factory managers, scientists, university teachers, writers, artists, and many others besides party officials — which many western observers have predicted would erode the Communist dictatorship . . . they get more money and better housing, and, in the middle and upper levels, country places, access to automobiles, and permission to travel abroad . . . but I doubt that many would risk their privileges and careers by political indiscre-

tions. Also," (and note this carefully, please) "Most are preoccupied with their own work."

Then Lindley comes to the core of the matter. Still discussing Russia, he says:

"The periodic whispers and political dissent come from the liberal arts faculties and students and from Lawyers and Creative Writers — **rarely from scientists, engineers, and industrial managers.**"

Believe me, as American industrial managers survey the slow erosion of freedom in American life, we are painfully aware of our own shortsightedness in giving too little attention to the climate of political and moral values out of which this erosion has developed. We, as part of management, are beginning to see that if we occupy our energies entirely with research and

MARVIN M. SCHMIDT *is an industrialist (Deere and Company) and president of the Iowa State College Foundation. This article is a condensation of his address before the Iowa Engineering Society in Des Moines.*

development, production, marketing, and finance, we can build a superlatively excellent economic machine, only to have it seized by the foes of freedom and transformed into an instrument of destruction for the liberties of the American people.

The Armor of Citizenship

We management people now have begun to realize that we have a bigger responsibility than that of management in the narrow and technical sense if we are to be true to our trust to the millions who have invested their savings in the capital enterprises we operate and to the many more millions who look to us for employment as free men and for goods and services in a free market. We know now that we must find the time in our days to break out of our confining shells as management technicians and assume our proper responsibility as *citizens* to help preserve a free society. And what we ask for ourselves, we feel we have a right to ask from the members of that professional *elite* — including engineers — who are associated with us in American industry. We have awakened to the solemn truth that productive capacity and technological skills do not of themselves spell freedom.

And so it is that the real obligation which industry lays upon the engineer is an obligation to put on the armor of alert and stalwart citizenship, in which you will sally forth from the protective cloister of the drafting room, and do battle in the hard, tough, and confusing world of conflicting ideas, swirling emotions, and highly charged propaganda.

This is the world where America's destiny will be decided. This is the world where the issue will be settled: Whether you and your descendants, along with the rest of us and our descendants, will be the kept and faceless automatons of a superstate, ruled by force and fear, or whether we shall safeguard our heritage of individual choice and personal decision.

Understand and Explain

Effective participation in this struggle requires that you understand, and — beyond understanding — speak out, on such issues as taxation, profits, and labor relations. It requires that you grasp the significance of a tax load that has risen from 11 percent of net national product in 1929 to one-third of that product now. It requires that you be prepared to explain the significance of this increase to all with whom you come in contact, and that you join in an organized way with others to check this trend before the tax load grows to 40, 50, or 60 percent of all we produce.

Effectiveness in the struggle for freedom requires that you take some personal part in rescuing the honorable word "profit" from the disrepute into which we have permitted designing men to drag it. The trend toward state control has been accelerated because we have allowed the institutions of free market capitalism to fall into disrepute.

Each of us, as part of American industry, has an obligation to re-establish profit in the minds of men for what it really is: a social institution that provides one of the foundation stones of liberty. In a competitive society, it is the reward for social service which the community, of its own free will, bestows on the enterpriser. If the concept of profit is destroyed, then we must turn our backs on the whole idea of free choice in economic affairs, and be prepared to accept the dictates of whoever is powerful enough to gain and hold control of the State.

Effectiveness in the struggle for freedom requires that you have the courage to speak out against the abuses inherent in labor union monopoly power, which lead inevitably to the sordid state of affairs so abundantly documented by the McClellan Committee.

You must be prepared to help strip the mask of hypocrisy and apology from the police departments, sheriff's offices, and — yes — even judges on the bench, who bow to the inordinate political power of union officials by blinding their eyes to bombings, beatings, arson, and physical violence on the picket line.

You may need to join with other good citizens in helping to establish local crime commissions that will concern themselves with upgrading the whole standard of law enforcement in this country as it relates not only to labor hooliganism but also to syndicated crime, juvenile delinquency, and a host of other sores that are eating away at the vitals of America.

In a description of the man of the future (August, 1959, Page A-4) we predicted the engineer-scientist would be drafted to lead the complex economic developments in coming years. Technology must mesh with our social and political culture. Unless engineer-scientist throws his effort into solving the problems of his community, we're going to have some badly broken gears in our progress machine.

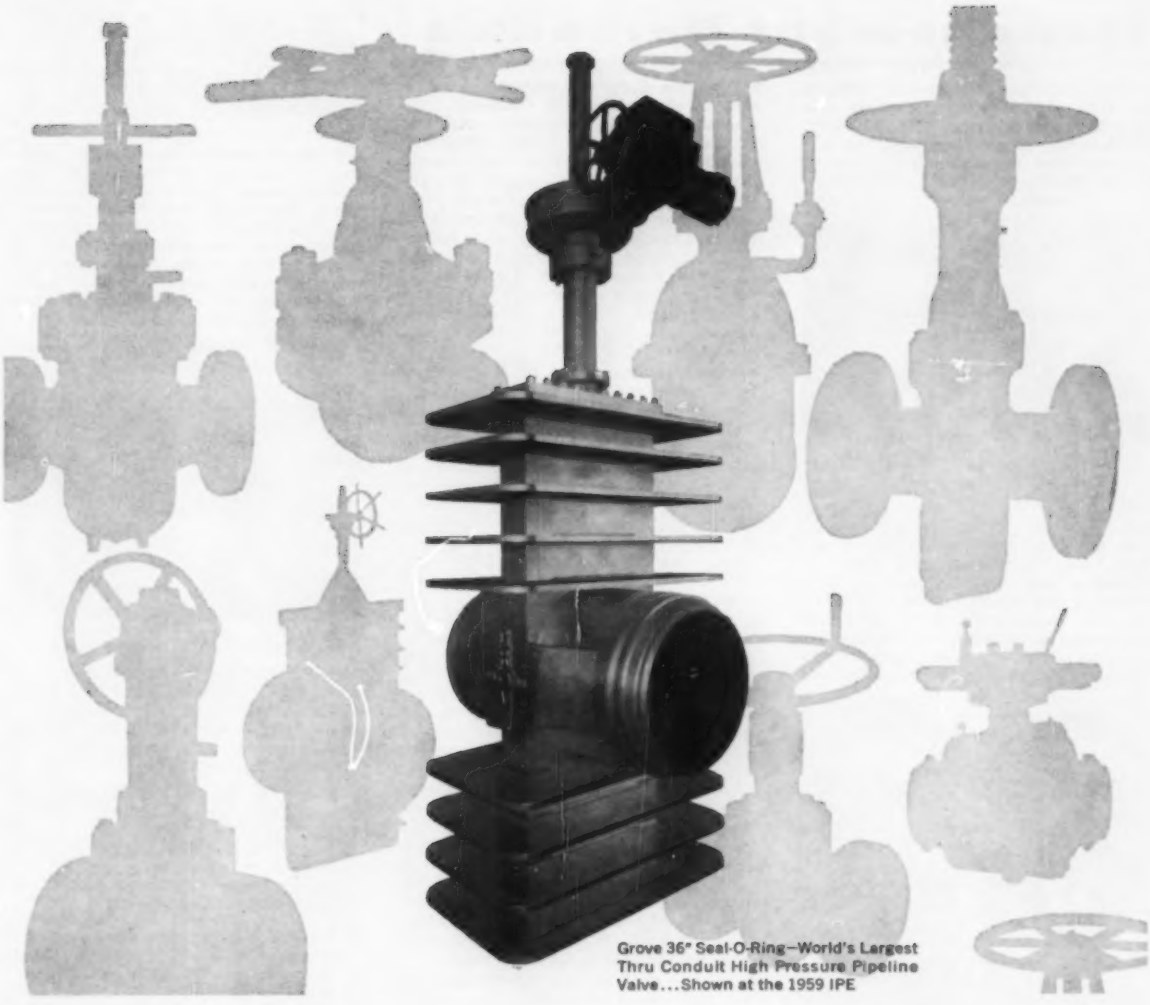
Promise of Freedom

In short, industry asks of the engineer that, in addition to being the best possible engineer, he be also — and above all else — a true American. Industry asks that the engineer first see for himself and then help others to see the glorious promise that the enterprise system holds for the future of our people.

The engineer, better than most, can document the record that this system has made and is making in eliminating poverty and fear of starvation, in conquering disease, in giving people the leisure for education and cultural fulfillment. All of these things it is doing, not with the lash and the knout, but while preserving liberty and freedom of choice.

It is for us who believe in the enterprise system — especially engineers — to think and act in terms of its promise, and to interpret it positively as the most dependable way to achieve the highest aspirations of the human spirit.

★ ★ ★



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Grove valves—with full thru conduit; an effective metal to metal primary seal plus "O" ring cleaning and sealing action—have been proven in over 6 years' use. The "O" rings, manufactured in Grove's own rubber plant, from Grove's own formula, are completely protected in an over-sized groove. No danger of cutting or abrasion resulting from gate action. Heavy mechanical springs keep the seats in line all the time. And you never lubricate . . . See your Grove man soon. Get all the facts.

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Management Personals

Paul J. Parker, director and formerly secretary and assistant treasurer, was elected vice president, international, of Phillips Petroleum Company. He will head the new international department. **W. F. Martin,** formerly assistant secretary and assistant treasurer, was named

P. J. Parker

W. F. Martin

to succeed Parker. The new department will conduct Phillips activities beyond borders of the U. S. under three divisions. The divisions and their managers are: exploration and production, **Harry D. Brookby;** sales and development, **John Getgood;** and operations, **W. L. Phillips.** Brookby was manager of the former international department, and Getgood was manager of the foreign sales and development department. Phillips was vice chair-

H. D. Brookby

John Getgood

man of the operating committee. All are headquartered in Bartlesville, Oklahoma, except Getgood, who remains in the New York City offices.

Sloan K. Childers was promoted to special representative and **W. W. Dunn** advanced to assistant foreign exploration director in Phillips Petroleum Company's international department. Both men will also be headquartered in Bartlesville. Chil-

W. L. Phillips

C. M. Kittrell

ders was previously assistant to the manager of the company's land and geological department and has recently been on loan to the international department. Dunn was manager of the land and geological department's Billings, Montana, division.

C. M. Kittrell was promoted to vice chairman of Phillips' operating committee, Bartlesville, replacing Phillips. **John E. Donnelly** was advanced to manager of the New York office of Phillips supply and transportation department, replacing Kittrell.

J. Arthur Kelly was appointed general attorney for Mobil Oil Company, the operating division of Socony Mobil Oil Company, Inc., for the United States and Canada. He was formerly general counsel.

Donald M. Tuttle, Lockheed Aircraft Corporation, Burbank, Calif., was elected president of the 65,000 member National Management Association at its 36th National Conference in Detroit. In the same election meeting, **Chester W. Brown,** of Harbison-Walker Refractories, was voted in as first vice president, and **Walter W. Lynn,** from Ohio Steel Foundry was named secretary-treasurer.

Claude Wild Jr. was appointed legislative representative in Washington, D. C. for Gulf Oil Corporation. He has been a counsel for Mid-Continent Oil and Gas Association in its Washington, D. C. offices.

Norman D. Farrell was promoted to assistant controller, Helmerich & Payne, Inc. In this post he will be responsible for the preparation of the company's financial statements and cost reports and will report directly to **R. G. Gambrell,** controller.

John H. (Jack) Francis Jr., Atlanta, Georgia, was appointed associate director of the Louisiana Petroleum Council. He succeeds **A. C. (Bill) Rose Jr.,** who has been named executive vice president of the Colorado Petroleum Committee with offices in Denver. Francis will join with LPC Director **Jimmie R. Major** in coordinating the petroleum industry's public affairs program from offices in Baton Rouge serving the state of Louisiana.

A. A. Buzzi was named financial vice president of Shell Oil Company. Buzzi, formerly controller, succeeds **A. G. Schei,** who retired after 35 years' service. **R. K. Burns,** assistant controller and assistant treasurer of Shell Chemical Corporation, succeeds Buzzi. **H. W. Egliht,** special assistant to controller, succeeds Burns.

Charles B. Duke was named manager of Sun Oil Company's newly-formed crude oil purchase and sales division. The new division has been formed to handle the company's expanded buying and selling activities of both domestic and foreign crude oil. It will become part of Sun's production department under the direction of **Jno. G. Pew,** production vice president.

Also transferred to the new division are **D. E. Norris,** formerly crude oil salesman, and **Robert E. Lee,** previously manager of crude oil supply and transportation. **John L. Olsen,** formerly assistant director-technical economics in the research and engineering department, replaces Duke as manager of Sun's refinery supply and distribution division. **Richard Fleming,** who succeeds Olsen, was formerly his assistant in technical economics.

Dr. Scott W. Walker, assistant manager of research for Pan American Petroleum and for 6 years a faculty member at Massachusetts Institute of Technology, has been named dean of the College of Petroleum Sciences and Engineering at the University of Tulsa. The new dean replaces **Harry N. Carter,** who has served as acting dean since **R. L. Langenhein** retired last spring. Langenheim had served as dean since 1929.

J. W. Yarbro, vice president, financial, Texas Pacific Coal and Oil Company, was elected a director of the company to fill the vacancy on the board created by the death last month of Sid W. Richardson.

Robert M. Youngs was elected president of The Louisiana Land and Exploration Company to fill vacancy caused by the resignation of **Jack O. McCall** who also resigned as a member of the board. Youngs will continue as chairman of the board.

Marvin W. Crowe, Lake Charles, Louisiana, was promoted to director of training for Continental Oil Company's manufacturing department, with headquarters in Houston. Formerly fire marshal and safety supervisor at Conoco's Lake Charles refinery, he succeeds **D. W. Devaney,** who recently transferred to Fort Worth as industrial relations manager for the company's southwestern region.

Angus A. Davidson, general attorney, was given the additional duties of legal coordinator of Sinclair Oil & Gas Com-

A. A. Davidson

L. L. Ware

pany. He will serve as coordinator of legal, lease, tax, claims and FPC matters. **Loren L. Ware,** vice president for exploration, was named coordinator for geological, geophysical, land, scouting, and conservation and proration.

Robert B. Woodin was appointed director of financial and public relations for Delhi-Taylor Oil Corporation. Woodin will supervise the preparation of all reports to stockholders, press relations, and assist in the preparation of budget and financial reports and analyses.

William H. Rowland Jr. was named manager of the finance and real estate division of Esso Standard Oil Company's treasurer's department. Since 1956, he has been a member of the New York headquarters staff of Esso's manufacturing department, engaged in profit and loss analysis of manufacturing projects, financial forecasting and product-sales contract negotiations.

Donnil M. Hillis was elected president and a director of the Four Corners Oil & Mineral Company, replacing **Edward A. Koester** who has resigned to re-enter private consulting practice. Hillis is a well-known geologist with a background in both mining and oil who has been associated with several major oil companies and for 10 years was chief geologist of The Capital Company, a wholly owned subsidiary of Transamerica Corporation.

Also elected a director was **Earl R. Howsam,** who is vice president and a director of the Denver Baseball Club and treasurer and a director of radio station KHOW, Denver. Howsam replaces **Dr. Edward L. Clark,** recently appointed director of natural resources for the state of Colorado.

George G. Thomson Jr. was elected vice president of Asiatic Petroleum Corporation. He will be responsible for public and government relations. His last assignment before joining Asiatic Petroleum Corporation in early November was with Shell International Petroleum Company Ltd.

Meetings

Jan. 22 — **Natural Gasoline Assn. of America,** Gulf Coast regional meeting, Robert Driscoll Hotel, Corpus Christi, Texas.

Jan. 31-Feb. 5 — **American Society of Testing Materials,** a committee D-2 meeting, Statler Hotel, Detroit, Mich.

Feb. 8 — **Canadian Petroleum Assn.,** Alberta division, annual meeting, Palliser Hotel, Calgary, Alta.

Feb. 8-10 — **American Assn. of Petroleum Geologists,** Rocky Mountain section, annual meeting, Billings, Mont.

Feb. 14-18 — **AIME,** annual meeting, Statler Hilton and McAlpin hotels, New York, N. Y.

Feb. 18-20 — **National Society of Professional Engineers,** winter meeting, Broadview Hotel, Wichita, Kans.

Feb. 24-26 — **National Assn. of Corrosion Engineers,** Tulsa section, Short Course, Mayo Hotel, Tulsa, Okla.

Feb. 25-27 — **Pipe Line Contractors Assn. of Canada,** Empress Hotel, Victoria, B.C.

Feb. 26 — **Natural Gasoline Assn. of America,** Permian Basin regional meeting, Lincoln Hotel, Odessa, Texas.

Mar. 2-4 — **API Division of Production,** southwestern district meeting, Statler Hilton Hotel, Dallas, Tex.

Mar. 6-9 — **American Society of Mechanical Engineers,** Gas Turbine Power and Hydraulic Conference, Rice Hotel, Houston, Tex.

Mar. 7 — **Canadian Petroleum Assn.,** annual meeting, Palliser Hotel, Calgary, Alta.

Mar. 10 — **Petroleum Equipment Suppliers Assn.,** northern Mid-Continent district, Mayo Hotel, Tulsa, Okla.

Mar. 14-18 — **National Assn. of Corrosion Engineers,** annual meeting, Memorial Auditorium, Dallas, Tex.

Mar. 16 — **Petroleum Equipment Suppliers Assn.,** eastern district, Duquesne Club, Pittsburgh, Pa.

Mar. 16-18 — **API Division of Production,** southern district meeting, Hilton Hotel, San Antonio, Tex.

Mar. 18 — **Natural Gasoline Assn. of America,** Oklahoma regional meeting, Biltmore Hotel, Oklahoma City, Okla.

Mar. 22 — **Petroleum Equipment Suppliers Assn.,** Gulf Coast district meeting, Shamrock Hilton Hotel, Houston, Tex.

Mar. 28-30 — **Western Petroleum Refiners Assn.,** meeting, San Antonio, Tex.

Mar. 29-31 — **American Power Conference,** Hotel Sherman, Chicago, Ill.

Mar. 30-Apr. 1 — **API Division of Production,** Mid-Continent district meeting, Broadview Hotel, Wichita, Kans.

Apr. 5 — **Petroleum Equipment Suppliers Assn.,** southern Mid-Continent district, Statler Hilton Hotel, Dallas, Texas.

Apr. 12-14 — **Petroleum Industry Electrical Assn. and Petroleum Electric Supply Assn.,** conference and exhibit, Kansas City, Mo.

Apr. 18-19 — **Conference on Automatic Techniques,** sponsored by National Conference Committee (ASME, IRE, AIEE), Cleveland-Sheraton Hotel, Cleveland, O.

Apr. 19-21 — **Southwestern Gas Measurement Short Course,** North Campus, University of Oklahoma, Norman, Okla.

Apr. 20-22 — **API Division of Production,** Rocky Mountain district meeting, Gladstone, Henning, and Townsend hotels, Casper, Wyo.

Apr. 20-22 — **National Petroleum Assn.,** semi-annual meeting, Hotel Cleveland, Cleveland, O.

Apr. 24-26 — **Independent Petroleum Assn. of America,** midyear meeting, Denver Hilton Hotel, Denver, Colo.

Apr. 25-27 — **Southern Gas Assn.,** convention, Buccaneer and Galvez hotels, Galveston, Tex.

▸ **O. V. Tracy** was elected to succeed **William Naden** as president of Esso Standard Oil Company. **Robert H. Scholl** succeeds **E. Duer Reeves** as executive vice president. Tracy has been a director of Esso Standard since 1954 and a vice president since 1956. His responsibilities on the Esso board have included all of the company's refining and petrochemicals operations. From 1952 until last year, he was president of the Enjay Company, Inc., petrochemicals marketing affiliate. He is a former general manager of Esso's chemical products department and has been closely associated with the development of chemicals from petroleum since he joined Esso Standard in 1930.

O. V. Tracy

R. H. Scholl

Scholl has been an Esso vice president and director since 1954. He joined Esso as a member of its law department in 1937, was named associate general counsel in 1946 and general counsel in 1949. He served as general counsel until his election as a vice president and director.

Naden, who had been president of Esso since August 1958, is now an executive vice president and director of the new Humble Oil & Refining Company. Reeves is now a vice president and director of the new Humble company. He had been executive vice president of Esso Standard for the last year.

▸ **Russell D. Karns** was named assistant treasurer of Pan American Petroleum Corporation. Karnes joined Pan American in 1934. He served in various capacities in the accounting, procedure and administrative departments until 1944, when he was named assistant to the president.

R. A. Feagan Jr. was named North Texas-New Mexico division gas superintendent of Pan Am. Feagan replaces **J. C. Conner,** who recently moved to Chicago on special assignment with Standard of Indiana.

▸ **Hulette F. Aby,** formerly general counsel to the Middle States Petroleum Corporation, was named associate general attorney of the Tennessee Gas Transmission Company.

▸ **W. R. Morton,** secretary and director, Cities Service Gas Company, ends 50 years of service with the company with his retirement December 1 in Oklahoma City.

▸ **James D. Willson** was named controller of Tidewater Oil Company. He succeeds **Russell D. Richardson,** finance vice president.

▸ **Tristan Antell** was elected a director of Drilling and Exploration Company, Inc. He is a limited partner in the investment banking firm of Hornblower & Weeks.

▸ **Charles B. Towill** was appointed public relations manager for BP (North America) Ltd. **R. Bryan Cooper,** who has completed nearly three years in New York for BP, leaves to take an appointment in the Information Department of the Group's head office in London.

▸ **Harry J. Peckheiser,** vice president and director of marketing for General Petroleum, will become resale marketing manager, Mobil Oil Company, with headquarters in New York, effective February 1.

Harry A. Bade Jr., division general manager of the New York City division, Mobil Oil, will become division general manager of the West Coast division, succeeding Peckheiser.

Clyde W. Port, general sales manager of General Petroleum, has been made division general manager of the Twin Cities division, Mobil, with headquarters in Minneapolis.

▸ **James Blakely Corbet** was named manager of the Canadian Petroleum Association's Alberta division. He succeeds **S. Douglas Turner,** Alberta manager for the past five years, who shortly is to assume the duties of general manager of the newly-formed Big Inch Pipe Corporation Ltd. Corbet comes to the association from the Alberta Government's Department of Mines and Minerals where, for 5 years, he has been departmental solicitor.

▸ **C. F. Baird** was appointed assistant treasurer of Standard Oil Company (New Jersey). He was formerly manager of the foreign exchange division in the treasurer's department.

▸ **F. J. Kelcher,** treasurer and one of the principal figures in the development of Pan American Petroleum Corporation, has retired from Pan American after nearly 42 years of service with the firm and its predecessor companies.

▸ **Howard A. Parker Jr.,** assistant to the general manager of manufacturing for the American Oil Company, has transferred to Chicago to take a post with Standard Oil Company (Indiana).

Parker was named manager of coordination and supply planning in the Standard (Indiana) supply and transportation department.

▸ **Dennis C. Shea,** assistant employee relations manager of Esso Standard Oil Company, has begun an assignment of about a year in Norway with another affiliate of Standard Oil Company (N. J.), Esso's parent company. **J. Edwin Hughey,** who has been operations superintendent at the company's Bayonne (N. J.) refinery replaces Shea.

DEATHS

▸ **John E. Kilgore,** 67, died December 13 in Dallas, Texas, following a brief illness. Author of Texas, oil proration laws and the Connally Hot Oil Act, he was a nationally recognized oil, gas, and taxation attorney.

▸ **K. A. Beede,** general superintendent of plants in the New York region for American Oil Company, died October 23 after a brief illness.

▸ **Dr. William H. Schuette,** 47, a vice president of The Dow Chemical Company and general manager of its Midland Division, died of a heart attack at the Midland Hospital Nov. 8. He had been stricken at his home a short time before.

▸ **Julian Nardi,** 62, chief mechanical engineer of Ford, Bacon & Davis, Inc., New York engineering and management consultants, was among the 26 persons who died in a Piedmont Airlines plane crash October 30 in Virginia.

▸ **Lester J. Richards,** 65, retired director of engineering for The Dow Chemical Company, died suddenly at his home in Midland, Mich., November 2. Death was attributed to a heart attack.

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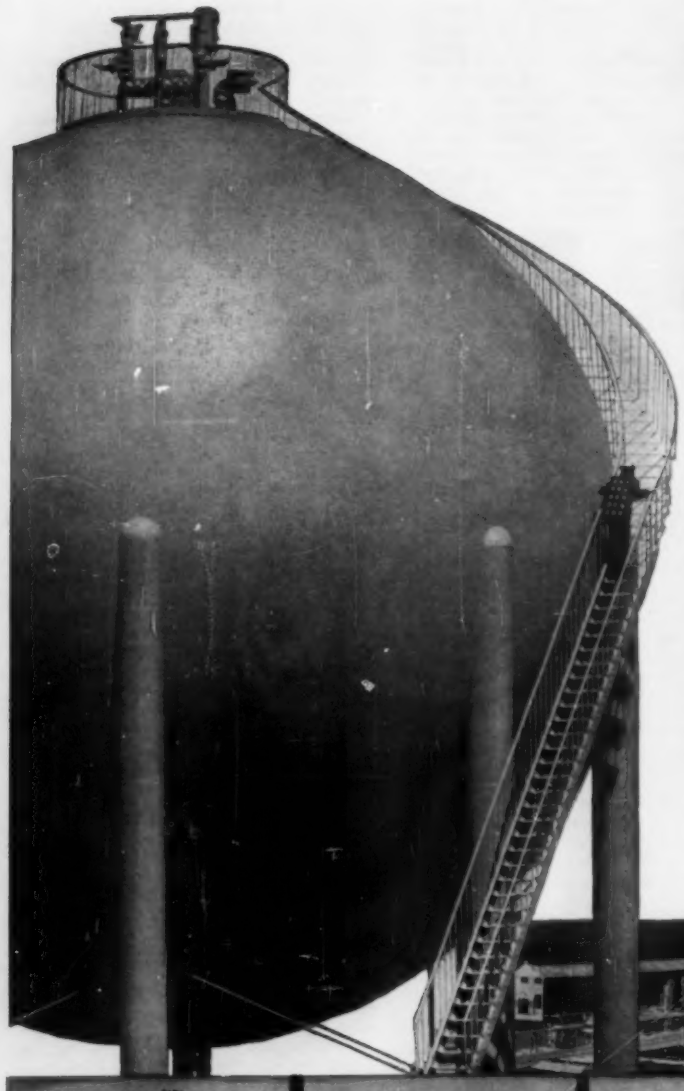

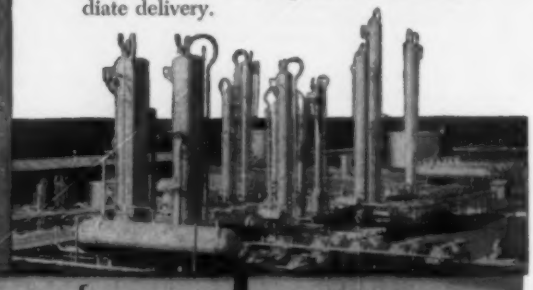

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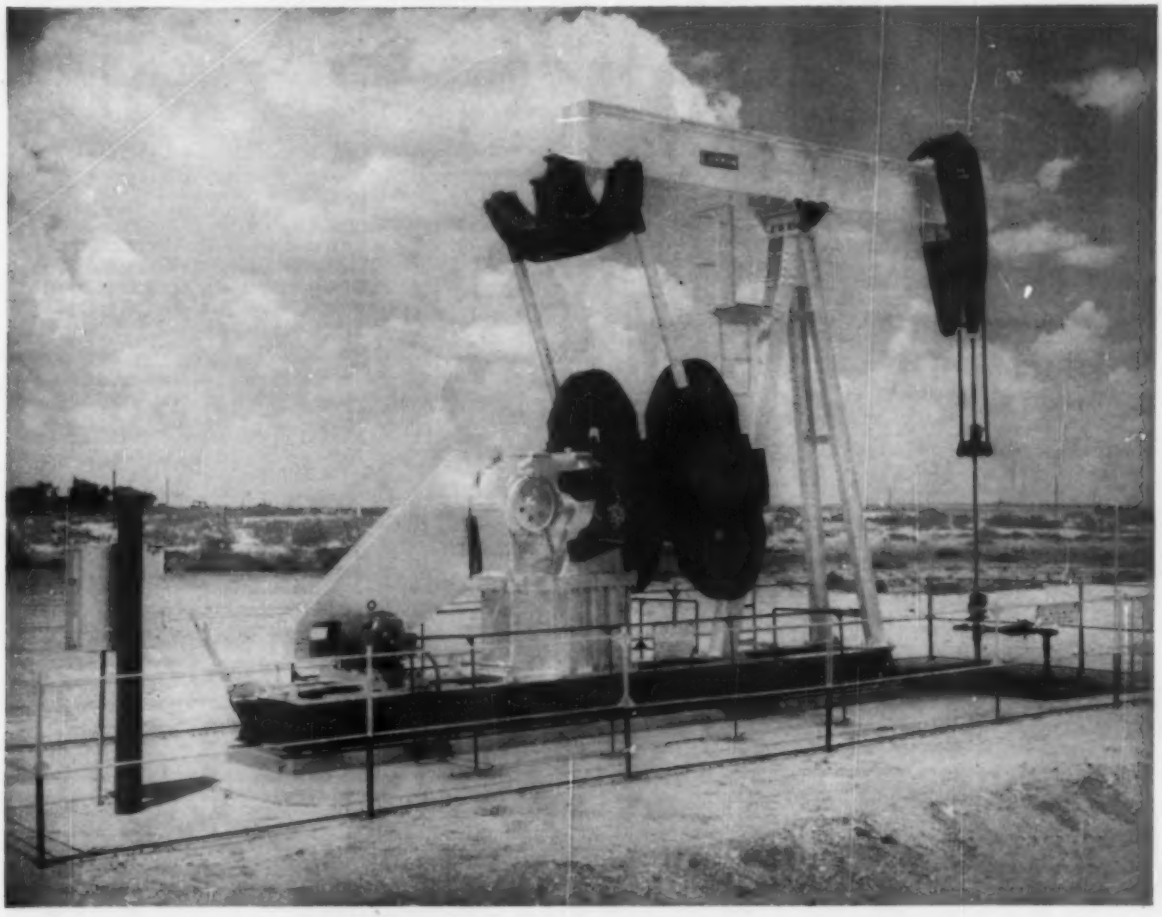

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TRADE PARADE

YUBA TO BUY WHITE CANYON. Yuba Consolidated Industries, Inc. and White Canyon Mining Company announced jointly that agreement has been reached, subject to White Canyon shareholders' approval, covering the sale of all of the assets of White Canyon to Yuba.

If approved, the former business of White Canyon will be operated by a wholly-owned subsidiary of Yuba with present operating personnel retained.

MANUFACTURER'S REPRESENTATIVES NAMED. Representatives for RCA mobile communications equipment in 4 states are: Kacy Communications, Inc., Kansas City, Mo. (Eastern and Central Kansas and Western Missouri); Electronic Enterprises, Inc., St. Louis, Mo. (Southern Illinois and Eastern Central Missouri); Memco, Inc., Memphis, Tenn. (Western Tennessee); Treece Communications, Inc., Litlte Rock, Ark. (Central and Western Ark.), and Electronic Distributors, Inc., Muskegon, Mich.

EUROPEAN MARKETING AGREEMENT. Shaffer Tool Works has announced completion of a manufacturing and marketing agreement with the Societe Nationale de Materiel Pour La Recherche et L' Exploitation du Petrole (S. N. MAREP) whereby the S. N. MAREP organization is licensed to make, use, rent and sell certain Shaffer well completion products throughout France, its territories, and major areas of Europe.

PURCHASES 12-ACRE SITE. Purchase of a 12-acre tract of land in Hawthorne (near Los Angeles), California, was announced by SKF Industries, Inc. in anticipation of any expansion requirements of West Coast facilities.

DISTRIBUTOR NAMED. Newly organized Olympic TBA Supply Company of San Jose, (Calif.) was named as Tidewater Oil Company's first distributor exclusively for Flying A tires, batteries and accessories. Located at 1366 N. 10th Street in San Jose, Olympic TBA Supply is headed by Robert H. McGillis.

WINS 1st PLACE IN SAFETY. The S. G. Taylor Chain Company, Inc. has just won its second consecutive safety award from the National Safety Council. The first place award, in the heavy fabricating division of the metal section, represents 416,910 man hours — July 1, 1958 thru June 30, 1959 without a lost time accident.

TO BUILD ROLLING MILL. A new rolling mill said to produce steel plates wider than now available throughout the world will be built by United States Steel Corporation at its Gary Steel Works in Gary, Indiana. Construction of the new facility follows U. S. Steel's announcement last year that engineering planning had been instituted for a new wide plate mill in the Chicago area.

CRANE APPOINTS AGENCY. Crane Co. has appointed N. W. Ayer & Son its advertising agency.

AD AGENCY NAMED. Burgess-Manning Co., Dallas, has appointed Dan Goodrich, Advertising, also in Dallas, to handle the company's industrial silencer division advertising account.

EXPANDS SALES REPRESENTATION. Burgess-Manning Company, Industrial Silencer Division expanded sales activities in the appointment of new representatives, which are: The Barth Engineering Co., Oakland, Calif., for the northern part of California and Nevada except Clark County. Colorado, Utah, Wyoming, Montana, Idaho, Western North Dakota and Kimball and Cheyenne Counties in Nebraska will be handled by E. N. Murray Co., Denver, Colo. Adams Engineering Sales, Decatur, Georgia, for Georgia and the Southern part of South Carolina. Northeastern Ohio covered by the Carlson-Rutledge Co., Cleveland, Ohio. In Canada: Bass Industrial Equipment of Canada, Ltd., Toronto, Ontario, for Ontario west of the 77th meridian. Assoc. Instrumentation & Controls Ltd., Montreal, Quebec, for Quebec and Ontario east of the 77th meridian. Belen-Lynn McGuffy Company, Ltd. and Edmonton, Alberta, for Alberta, Saskatchewan and Manitoba.

OPENS NEW REGULATOR FACTORY. American Meter Company formally opened a 65,000 sq ft addition to the plant at Fullerton, California. It more than doubles the plant's size, houses all production, customer service, warehousing and research operations of the Reliance Regulator Division. George W. Stevenson is vice president and general manager of West Coast operations and Carl M. Brehm is plant manager.

SALES OFFICES MOVE. Atlas Powder Company's explosives and chemicals sales offices in San Francisco moved to new quarters at 2036 Pioneer Court, 20th Ave. Executive Center, San Mateo, Calif.

ACQUIRES TWO FIRMS. Beckman Instruments, Inc., has acquired two firms as part of its continuing program to expand existing product lines. They are Harold Kruger Instruments, San Gabriel, Calif., and Tool-Lab, Inc., of Escondido, Calif.

DISTRIBUTOR FOR OHIO. The W. W. Williams Company, Columbus, Ohio, was appointed crane-excavator-rotary drill distributor for Ohio by Bucyrus-Erie Co. In addition to Ohio, The W. W. Williams Co. will cover the counties of Boone, Kenton, and Campbell in Kentucky, and the counties of Ohio, Switzerland, Dearborn, Ripley, and Franklin in Indiana.

WESTON HYDRAULICS, LTD. West coast subsidiary of Borg-Warner Corp. manufacturer of aircraft and missile components, has opened its new 100,000 sq ft plant at Van Nuys, Calif. The structure, built on a 33-acre tract, consolidates a number of previously scattered operations and special installations include separate, dust-free, temperature controlled rooms for precision manufacturing and testing of missile components. Research and development facilities include a separate building which houses test cells for operation of units using high temperature fluids and gases. Adjoining this area are explosion-proof chambers from which tests may be observed in safety.

MERGER APPROVED BY DIRECTORS. Plans for the merger of Consolidated Electrodynamics Corp., with Bell & Howell Company were approved by directors of both companies. The plans will be submitted to shareowners.

CEC would operate as a subsidiary company under its present name. Philip S. Fogg would continue as president and chief executive with present management and personnel. Three CEC directors have been nominated to Bell & Howell's board, they are Fogg, Dr. Robert F. Bacher, and Dr. Frederick C. Lindvall.

L. A. POLICE GET RADIOPHONES. The city of Los Angeles has contracted with Motorola Communications & Electronics, Inc., for 500 Motorcycle "Dispatcher" radiophones operating in the 152-174 mc frequency band for usage by the police department. Delivery of the units is to start early in 1960.

JOINT ACQUISITION. The Dow Chemical Company announced that its Swiss subsidiary, Dow Chemie A. G., and The Rio Tinto Company, Ltd., of London, England, have jointly acquired the share capital of Thorium Ltd. from Imperial Chemical Industries Ltd. and Howards of Ilford, former joint owners.

SUBSIDIARY CHANGES NAME. The British subsidiary of The Dow Chemical Company — Dobeckmun Britain Ltd. — has changed its name to Dow Chemical Company (U. K.) Limited and broadened the scope of its activities.

MOBILE DISPLAY TRUCK. Fisher Governor Company has introduced a new mobile display truck as an educational service to customers in the oil production industry. This unit is equipped with sectional and working models of Fisher controllers and production equipment, the educational movie, "Muscles of Control," and a supply of literature.

KIMBLE NAMES DISTRIBUTOR. Fischer & Porter Co. has been appointed a distributor of the full line of laboratory glassware manufactured by Kimble Glass Co., a subsidiary of Owens-Illinois.

OPENS NEBRASKA SUPPLY STORE. The National Supply Company has opened an oil field supply store at Kimball, Nebraska, with G. W. Haase as manager. The store is under the jurisdiction of Luther M. Miller, manager of the Colorado district, and serves Kimball and Banner counties, Nebraska, and a portion of Laramie County, Wyoming.

STEEL AND IRON COMPANY MERGER. Pittsburgh-Des Moines Steel Company completed merger negotiations with Hammond Iron Works. The combined company will be known as Pittsburgh-Des Moines Steel Company. Pittsburgh-Des Moines also acquires the foreign affiliate of Hammond Iron Works known as the Hammond Latino Americana S.A.

At a meeting of the board of the combined companies, the following officers were elected: J. E. Jackson, chairman of the board; W. R. Jackson, president; R. Y. Kopf, v.p.; T. W. Fauntleroy, v.p.; C. A. Fegtly, v.p.; R. E. Kramer, v.p.; T. G. Morris, secretary-treasurer; and M. P. Cook, ass't. secretary. The executive committee is composed of J. E. Jackson, W. R. Jackson and R. Y. Kopf. The administrative offices of the combined company will be in Pittsburgh, Pa.

DISTRICT SALES OFFICE AT PAMPA. Establishment of a district sales office in Pampa, Texas, was announced from Houston headquarters of The Parkersburg Rig & Reel Company. The new office is located at 116 S. Ward in Pampa and is staffed by district salesman Don L. Henry.

R & D CENTER OPENED. Parker Seal Company's new Research and Development laboratory, said to be the most modern of its kind devoted exclusively to specialized seals and sealing problems in aircraft, missiles and industry, has been opened in California. The laboratory is housed in a new 20,000 sq ft building alongside the main headquarters building at 10567 Jefferson Blvd., in Culver City. A part of the area is also devoted to some administrative offices and special processing.

Special report to owners of Traxcavators, D6 and D4 Tractors

CAT CATERPILLAR

Parts you can trust
Dependable round-the-clock service

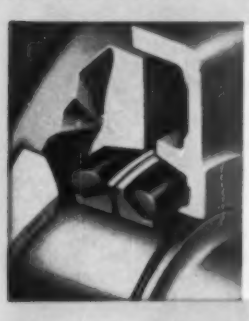
Now available...lifetime lubricated rollers...two-way savings...

ELIMINATE MAINTENANCE GIVE LONGER LIFE

Here's another cost-cutting improvement for Traxcavators and both D6 and D4 Tractors . . . lifetime lubricated rollers. Now you can eliminate on-the-job shutdowns for greasing. And you get longer life from rims, flanges, internal parts. The payoff . . . reduced replacement costs, savings in time.

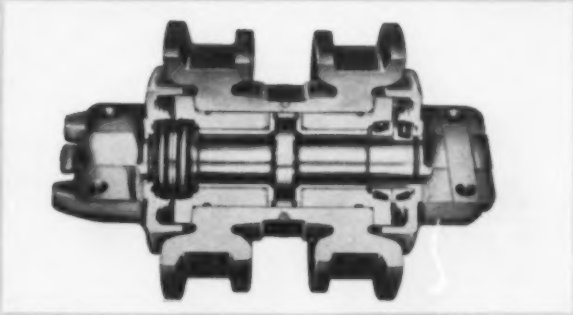
How maintenance is eliminated—the new Cat-built rollers are lubricated when first installed. They are equipped with floating ring seals that keep lubricant in . . . grit out . . . for the life of the rollers. Only when rollers are disassembled for rebuilding will relubrication be necessary. And the original metal rings can be reused.

New floating ring seal . . . only four parts, no springs. The roller seal employs two alloy metal rings and two rubber "O" rings. The metal rings, much harder than the best file steel, have lapped faces, smoother than glass. These faces taper slightly toward the inner edge forming a sealing area at the outer edge. As wear occurs, the sealing area moves gradually inward, maintaining a perfect seal for thousands of hours.



The "O" rings keep constant pressure on the metal rings. Lubricant can't get out. Grit can't get in. There are no springs or diaphragms to weaken, wear or become damaged. The "O" rings are made of special compound to resist oil, heat, cold.

Why do roller parts last longer? Grit is permanently sealed out. Big lubricant reservoirs (with strategically located oil passages) insure ample supply of lubricant to moving parts. Oil instead of grease is used for roller lubricant. Oil dissipates heat faster, circulates more freely than grease. These features assure you of longer shaft and bearing life. Longer bushings with extra-thick flange assures rigid support. Large sleeve bearings provide ample bearing area. Larger diameter, deep-hardened shafts withstand higher shock loads. Beam strength has been increased 63% for D6 shafts; 185% for D4 shafts. Resistance to side thrust is



greatly increased in D4 shafts by a 25% wider center flange and 73% more thrust-bearing area.

Why do rims and flanges last longer? The new two-piece roller shell has greater strength and impact resistance. Special heat-treat process provides extra-hard and deep wear surfaces. Ample steel under tread gives strong support to resist shock loads. Thicker flanges combat peening over. Overlapping center joint maintains rigid shell without separate hub.

Easy installation is achieved by use of snap rings to hold the seals and end collars in place before mounting. End collar bolt holes will line up easily with track roller frame holes during installation.

Millions of hours of proof—the toughest track rollers yet. Cat lifetime lubricated rollers have been subjected to extensive and exhaustive on-the-job tests for over 5 years. Working on all types of job conditions, these time-tested rollers have proved to be unequaled. And machine-owner reports prove that Cat lifetime lubricated rollers can't be beaten for low-cost, minimum maintenance operation.

See your Caterpillar Dealer. He'll give you the full story on this time-saving, money-saving undercarriage component.

Caterpillar Tractor Co., General Offices, Peoria, Illinois, U.S.A.

SERVICE TIP: When rebuild time finally comes, be sure to keep the metal rings matched in original pairs, being careful not to nick or mar the lapped surfaces.

CATERPILLAR

Caterpillar, Cat and Traxcavator are Registered Trademarks of Caterpillar Tractor Co.

3-STORY ADDITION. Petrolite Corporation announced the start of construction of a 12,000 sq ft, 3-story addition to Tretolite Company division's present administration building located in Webster Groves, Missouri.

WEST GERMAN PLANT EXPANSION. Rockwell Manufacturing Company will build a new 150,000-sq ft addition to its plant at Pinneberg, West Germany, for the manufacture of liquid meters, valves and woodworking power tools for the European and world markets. The new building will house production facilities for larger sizes of Rockwell-Nordstrom lubricated plug valves. Smaller sizes are already being produced.

CENTRALIZATION PLANS. The Petreco division of Petrolite Corporation announced that it will be responsible for all equipment sales and process engineering for the Petrolite domestic and Canadian divisions.

The Tretolite chemical desalting process equipment now will be marketed by the Petreco organization. Tret-O-Lite desalting chemicals will continue to be distributed and serviced by the Tretolite division refinery service staff. Equipment and processing sales will be managed by Charles P. Siess Jr., transferred to the Houston headquarters of Petreco division from the Tretolite division at St. Louis. Also transferred to Houston was J. R. (Bob) Moechel, in charge of sales of chemical desalting process equipment. Sales of electric processing equipment will be under the direction of H. R. (Reg) Jarvis, also in Houston. Logan C. Waterman, formerly sales manager for Petreco processing equipment, has been promoted to director of a new development department.

EXPANDS IN CALIFORNIA. The Tretolite Company of California division of Petrolite Corporation has broken ground for its complete new $2,000,000 chemical manufacturing facility at Brea, California. Completion of the new construction is expected before mid-1960, at which time the company will move from its present offices and manufacturing plant in Los Angeles. It will include an administration building, 3 laboratory buildings, and complete, highly automated manufacturing facilities.

▸ **American Meter Company.** Russell W. Wetjen was named vice president and general manager of the recently acquired Granberg Corporation. He is also vice president and general manager of the Buffalo Meter Company.

▸ **Beckman Instruments Co.** Stuart N. Davidson was appointed corporate contracts administrator. Davidson joined Beckman after serving as senior contracts administrator with Northrop Aircraft, Inc. Jane Bishop was named supervisor of advertising services. She formerly served as advertising production assistant for Beckman's Helipot Division.

Roy W. Holm is named corporate employment manager after serving as employee relations manager for the company's Spinco Division and subsidiary Shockley Transistor Corp., at Palo Alto, Calif., and Berkeley Division, Richmond, Calif.

▸ **Tube Turns Division of Chemetron Corporation.** James M. Gloor was named works manager to free John A. Henby, vice president-production, for new responsibilities related to current and future manufacturing operations. Morry T. Wakefield, formerly industrial relations director, succeeds Gloor as production superintendent. Max B. Densford, wage and salary administrator, is promoted to personnel manager, Henry H. George to chief engineer, product engineering and research department and Everett C. Rodabaugh, principal research engineer, assigned to added duties as head of a newly formed process research group. Fred C. Smith, director of quality control, was assigned to added duties as special research project head. Arthur McCutchan has rejoined Tube Turns as a special projects engineer.

▸ **U. S. Industries, Inc.** Thomas H. Mullen was named director of customer relations of the USI Technical Center in Pompano Beach, Florida. He will direct all proposal and contract administration activities of the Technical Center.

▸ **Southern Pipe Division of U. S. Industries, Inc.** William I. Ballentine Jr., Whittier, California, was named chief engineer responsible for research and development, inspection, industrial engineering, and plant engineering functions.

▸ **United States Steel Corporation.** Leslie B. Worthington was elected president and chief administrative officer of United States Steel Corporation, succeeding the late Walter F. Munford. He was also elected a director and chairman of the executive committee and becomes chairman of the operations policy committee in Pittsburgh.

E. B. Speer, presently vice president — operations — steel, was appointed administrative vice president — central operations (steel and coal), succeeding Edwin H. Gott, recently named executive vice president — production. R. W. Graham, general manager, operations — steel, succeeds Speer.

▸ **Byron Jackson Tools, Inc.** W. M. Burstall, superintendent of oil tool plant 1, has been promoted to the position of chief tool engineer, methods and routing department. Gale Smith succeeds Burstall.

▸ **Borg-Warner Corporation.** Howard A. Schmeal has been elected vice president, treasurer and secretary and M. R. McLary elected executive vice president and manager of the Ingersoll Products Division.

Jalmer E. Swanson, 68, former president and vice chairman of the board of Graver Tank & Mfg. Co., died suddenly of peritonitis on November 14. He had served Graver for 47 years and was Graver's oldest employee in years of service. He started in Graver's East Chicago shop in 1912 and had worked successively in field erection, in the offices, and in sales. After a long term as sales manager, he was elected vice president in 1944 and executive vice president in 1948, and served as president during Graver's centennial celebrations in 1957. He was named vice chairman of the board in May 1958. During his presidency, Graver became a division of Union Tank Car Company in 1959, and he stepped down to the role of consultant.

▸ **Universal Oil Products Company.** Emil Pfister recently joined the company as a consultant. Until his recent retirement, he was with Asiatic Petroleum Corporation in charge of all technological matters connected with the refining and petrochemical industries.

▸ **Union Carbide Chemicals Company.** Lester D. Polderman was promoted to product sales manager of the Union Carbide Corporation division. He served as assistant product sales manager since 1958.

▸ **Union Asbestos and Rubber Company.** Paul K. Benjamin Jr., was appointed product manager, packing department, Fibrous Products Division. He has served the firm as a special project coordinator and as a member of the financial staff.

▸ **Wolverine Tube, division of Calumet & Hecla, Inc.** R. E. Seaton was promoted manager of processing and power sales. He was formerly technical sales supervisor.

▸ **Yuba Consolidated Industries, Inc.** T. B. Leech was named vice president and director of export sales. Formerly sales manager and a director of Petro-Chem Development Company in New York, a firm acquired by Yuba in August 1959, Leech will coordinate the export sales program for all 15 Yuba divisions from New York sales offices.

▸ **Armco Steel Corporation.** After 57 years of service with Armco, Charles R. Hook resigned as chairman of the board but will continue as a director of the company.

▸ **Allis-Chalmers Mfg. Co.** New appointments for the Pacific region are: J. A. Longley, regional representative for transmission and distribution equipment; T. E. Meyers, manager, San Francisco district, and G. K. Lewis, manager, Portland district. Longley had been in the San Francisco district since 1946 and manager for the last nine years. Meyers had been manager of the Portland district since early in 1959, and Lewis had been manager of utility sales in San Francisco.

W. L. Haslam was appointed manager, chemical and metal sales, San Francisco district, and Alan Purchase named manager, industrial sales, Los Angeles district. Haslam was a sales representative in Los Angeles and Purchase had been manager of industrial sales since 1956.

▸ **Radio Corporation of America.** Edwin M. Hinsdale was named chief engineer, RCA Communications Products Department. Prior to his present post, he served on the technical staff and with the International Division.

▸ **Reed Roller Bit Company.** Two transfers and reassignments within the export sales division are: John T. Orton, sales division manager for Northern South America since 1957, assigned to London, England, as sales division manager for the Eastern Hemisphere. He replaces T. C. (Ted) Lemcke, who has been reassigned to Reed's headquarters in Houston to assume new sales responsibilities.

▸ **Shand and Jurs Company.** George A. Fournier was appointed manager of the New York district sales office. R. F. Ley, former manager of that office, will carry out special assignments on growing export accounts, in addition to his work with selected domestic accounts. Shand and Jurs is a subsidiary of General Precision Equipment Corporation.

▸ **Sargent Engineering Corporation.** C. W. "Bill" Floyd Jr. has been appointed systems division engineer, petroleum production systems division. He formerly was a consulting electrical engineer.

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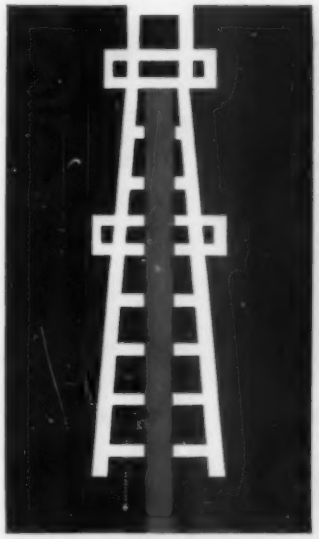

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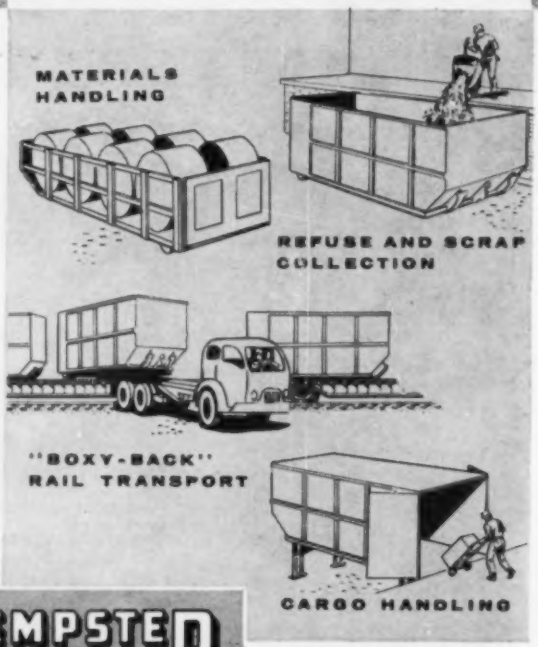

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Genesys Corporation. Recently appointed sales manager was Robert M. Cornforth who under the direction of John F. Davis, vice president, will head sales activities of the electronic firm's control computer system for process and pipeline applications.

Gulf Coast Machine & Supply Company. Jay Hembree has joined the sales organization as West Texas representative. Don Fagan has transferred from Odessa to Pampa, Texas.

General Controls Company. Stanley B. Graft has joined the company as export manager in the International division. He is the assistant to Remy H. Ludwig, director. Malcolm L. Johnson, formerly sales engineer with the factory branch office in Chicago, was transferred to Cincinnati where he is the new district sales engineer. Lewis M. Bound Jr., was named Northern California sales representative for its Tork-Master and Foster Engineering division products.

Grove Valve and Regulator Company. Three new production valve salesmen representatives are: Daniel Lee Nicholson in the Oklahoma area; J. W. Lowrance Jr., the Rocky Mountain region; and Gil A. Lastrapes Jr., the New Orleans area.

General Electric. Paul D. Williams was named manager of marketing administration for the Communication Products Department's national headquarters at Lynchburg, Va.

Baroid Division National Lead Company. L. W. Jones was named sales manager foreign operations. He will represent Baroid's overseas affiliates and the Baroid Division's foreign operations. W. B. Boutwell Jr., formerly district superintendent at Tyler, Texas, has been appointed sales representative in foreign operations and will transfer to the Houston headquarters. O. L. Riley Jr., formerly area engineer at Long Beach, Calif., has been transferred to Alaska as sales representative. W. T. Sherman, district superintendent at Brownfield, Texas, has been transferred to Houston as sales representative in the Lower Texas Gulf Coast Area.

Bucyrus-Erie Company. Frank T. House was appointed sales promotion manager and Herman A. Burkhardt, publicity manager. Public relations will continue to be handled by D. W. Harris.

Babcock & Wilcox Company. Robert A. Barr was elected a vice president assuming charge of the refractories division. He replaces James E. Brinckerhoff, retired.

J. P. Craven was elected a vice president in charge of Boiler division's manufacturing department. He succeeds Paul H. Setzler, who resigned.

Cooper-Bessemer. J. M. Brannaman was appointed to the post of branch manager. He will initiate the newest Cooper-Bessemer field office, 431 Union Trust Building, Pittsburgh, Pennsylvania. This office, under the direct supervision of F. M. Devin, vice president and district manager, will handle sales and engineering contacts in the territories of eastern Ohio and western Pennsylvania.

Gates Rubber Company. Clarence H. Mingle, director of marketing, was elevated to an executive vice presidency. He has been a Gates vice president since 1944. Frank S. Bosley, vice president in charge of manufacturing and engineering, was named executive vice president in charge of manufacturing.

Ralph Heckman, advertising director for the past 26 years, was named vice president in charge of advertising research and planning. Taking his place as administrative director of the advertising department is Robert E. Holwell, who has served in sales, engineering and research. Three shifts in the marketing division are: Charles J. Korsoski, a vice president, becomes head of the "private brands" sales division. Drexel D. Minshall, becomes head of the automotive jobber and hardware sales division, and B. C. Emerson, who has been employed in the industrial marketing department, becomes sales manager of Gates' "private brand" tire sales department, under Korsoski.

Houdaille Industries, Inc. Eric G. Boehm was named general manager of the Manzel Division in Buffalo, New York. He was general manager of the Buffalo Bolt Division of the Buffalo-Eclipse Corporation.

Hughes Tool Company. Park L. Myers was promoted assistant vice president-sales. For the past 4 years Myers has been domestic sales manager, responsible for the company's sales in the U. S. and Canada. Myers succeeds to the position vacated by W. H. Siems, promoted to vice president-sales.

Jones & Laughlin Supply Division. G. R. Cain, salesman at Kermit, Texas, was transferred to Borger, Texas.

International Harvester Company. J. D. Gladden was named sales manager of the new Southwest region of the Construction Equipment Division. He was assistant manager of the Plains region.

Jet Research Center, Inc. Pete De Frank was appointed to the combined position of manager of research and manager of the perforation flow laboratory.

Linde Company. James A. Hudson, formerly Midwestern manager of gas products sales, was appointed Western sales manager of bulk gas sales by Linde, division of Union Carbide Corporation. He will be engaged in the sales and promotion of on-site tonnage oxygen plants to the steel, chemical, and petroleum industries.

Barrett Division, Allied Chemical Corporation. Wesley E. Gatewood was named director of field sales. He formerly was director of sales training and promotion.

Columbia-Geneva Steel Corporation. J. D. McCall was named president with headquarters in San Francisco. McCall succeeds Leslie B. Worthington, who was elected president of U. S. Steel.

Corning Glass Works. Joseph S. DeMaio has joined the company as advertising and sales promotion manager of the Electrical Products Division.

Merla Tool Corporation. Johnnie Valdez was named special sales representative for the Dallas, Houston, Fort Worth, Oklahoma City and Tulsa areas.

Minnesota Mining & Manufacturing Company. C. P. Pesek, vice president for engineering and staff manufacturing, was elected to the board and also elected to the executive committee.

National Supply Company. Allen P. Colby, advertising manager and with the company for 38 years, has retired. J. W. Gillespie, sales representative at Billings, Montana, has also retired after 46 years. Charles J. Spiker was appointed manager, oil field accounting. He was named plant controller at the Toledo plant in 1957.

John C. Madden was appointed sales manager, oil country tubular products. He succeeds W. R. Ryburn, who has resigned. Madden previously was in the export division as tubular manager.

Pittsburgh Coke & Chemical Company. John W. Martin was named project manager of the commercial development department. He was formerly with Koppers Co. and the Virginia Smelting Co.

Milwhite Mud Sales Company. George E. Conner was elected president. In 1958 he was elected to serve as executive vice president of Milwhite. Geo. W. (Bill) Bowman has joined the staff as sales representative for Milwhite throughout the important focal points in the U. S. and will headquarter in Ft. Worth, Texas. James N. Statton, salesman in New Orleans, has been transferred to Midland, Texas. Also in Midland, Jack Nini has joined the sales force and Ben Anderson was appointed division manager of the West Texas Division.

Collins Radio Company. Frederick F. Robinson was elected a director. He is president and director of National Aviation Corporation.

Cameron Iron Works. Re-elected are: J. S. Abercrombie, president and chairman; R. H. McCullough, secretary and treasurer; Herbert Allen, vice president and general manager. In addition, six new vice presidencies created are: A. D. Blackledge, vice president and assistant manager; W. R. Davis, vice president and manager Pressure Control Equipment Division; J. H. Grubb, vice president and manager International Division; J. W. Brougher, vice president and manager Special Products Division; C. G. Hayward, vice president and controller; and J. B. Ogden, vice president and manager industrial relations.

Catalytic Construction Company. Richard P. Klopp, formerly manager of sales, Gulf Coast area, has been named manager of commercial sales.

California Research Corporation. Dr. R. G. Smalley was promoted to senior research geologist, inorganic geochemistry, in the geology division at the La Habra Laboratory. In the Richmond Laboratory: Dr. M. R. Barusch was appointed research associate in organic chemistry; J. A. Miller named supervising research engineer, engine lubricating oil division; D. F. Searle appointed supervising research chemist, chemicals exploratory research division; Dr. N. J. Aroyan promoted to supervising research engineer, chemicals process development division; and Dr. F. A. Stuart moves to the position of supervising research chemist, petroleum products research division.

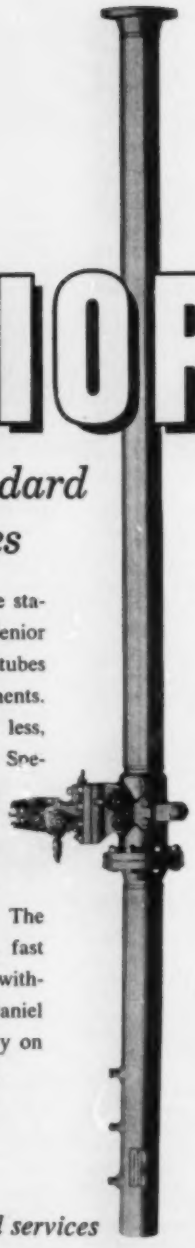
J. I. Case Company. John H. Brinker has just resigned his post as vice president and general manager of the Permaglas Division of the A. O. Smith Corporation to accept the position of executive vice president and a member of the J. I. Case board.

Daniel Orifice Fitting Company. Rex W. Landry has joined the firm as application engineer in charge of meter station design.

Ethyl Corporation. James B. Lonergan was appointed advertising manager and will be responsible for all Ethyl advertising, will serve on the staff of Russell B. Weston, director of advertising, sales promotion, and merchandise management.

Drilling Tools, Inc. W. W. Gratehouse has been made a vice president and J. E. Pattillo Jr., promoted to sales manager. Gratehouse will continue to manage Louisiana operations in addition to new administrative duties and maintain headquarters in Lafayette. Pattillo will supervise the sales activities of the offices at Lafayette, Houma and Sulphur, La., as well as the Texas Gulf Coast operations, located in Houston.

Dow Chemical Company. Macauley Whiting was appointed general manager of Dow's Midland Division. He succeeds the late Dr. William H. Schuette, vice president and general manager of the Midland Division, who died November 8.



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189

Books To Read . . .

The Oil Depletion Issue, *by John H. Lichtblau and Dillard P. Spriggs, Published by Petroleum Industry Research Foundation, Inc., 122 E. 42nd Street, New York, N. Y. Pages, 148. Price, $2.60.*

Percentage depletion tax deduction for crude oil producers is essential to maintain existing price levels for gasoline and other oil products, according to the above research study on the subject. Without this tax feature, exploration for oil would be uneconomical at today's costs and prices. Hence, the elimination or substantial reduction of the current percentage depletion rate would necessitate an increase in price which consumers pay for oil products, say the authors, both petroleum economists.

Percentage depletion incorporated into every U. S. income tax act since 1926, permits oil producers, in computing their taxable income, to deduct a maximum of 27.5 percent of their gross income derived from crude oil and natural gas sales. An inquiry into its merits by the House Ways and Means Committee began December 1, as part of the Committee's overall review of the U. S. tax system.

The study points out that the percentage depletion rate of 27.5 percent was calculated to reflect the true replacement value of oil in the ground. In recent years, however, it has usually represented less than this value and in the future "it will probably cover a steadily declining share of the cost of crude oil reserves."

Problems and Practices in Industrial Relations, *Published by Personnel Division, American Management Association, 1515 Broadway, New York 36, N. Y. Pages, 155. Price, $3.75; AMA members, $2.50.*

This is one of American Management Association's symposiums in print, with several gems in the collection. The report includes discussions of current problems and practices in such areas as human relations, labor relations, and personnel administration.

In the first part, covering Human Relations, the paper of James M. Rogers on individualism was published in The Petroleum Engineer, May, 1959. It is a significant case history.

There are a number of good idea-filled articles in the report and there are a few that indicate personnel management is breeding another new language that will fence out fellow-workers if nurtured. We hope the pseudo-technical expressions die a quiet death.

Petroleum Facts and Figures, *published by American Petroleum Institute, 50 W. 50th Street, New York 20, N. Y. Pages, 475. Price, $4.50. Free to API members.*

Prepared by the Institute's Committee of Public Affairs, this volume provides a comprehensive statistical history of the 100-year-old oil industry. Included are data on production, refining, transportation, marketing and utilization. This centennial edition carries for the first time historical highlights on each of the industry's major divisions, a glossary and a bibliography.

Oil On Stream!, *by John L. Loos. Published by the Louisiana State University Press, Baton Rouge 3, Louisiana. Pages, 411. Price, $6.*

This volume is a history of Interstate Oil Pipe Line Company from the formation of the Oklahoma and Louisiana companies in 1909 until early 1959. It covers all the important construction and operating activities of these companies in the nine states in which they have done business during the past half century. It sets forth the developments which have occurred in the techniques and equipment for building, running, and maintaining the pipeline system. Noteworthy changes in corporate structure and in management personnel and techniques are described, and important statistics of the business are recorded. In sum, this work presents in full the story of the origin, development, and activities of one of the country's major crude oil pipeline organizations.

The Elements of Style, *by William Strunk, Jr. Published by The Macmillan Company, 60 Fifth Avenue, New York 11, New York. Price, $2.50.*

In July, 1957, *The New Yorker* printed a piece by E. B. White about a small book called "The Elements of Style" by William Strunk, Jr., late Professor of English at Cornell. White recalled that in his student days it was known on the campus as the *little* book. He paid tribute to the author for his fixed devotion to the cause of lucid, spare prose; his unapologetic dogmatism in setting guide lines for accurate, forthright English. Today "The Elements of Style" is restored to the world of letters. It is a book for every man who has to write a report. E. B. White has made judicious revisions but the pith and pungency of the original remain.

White's final chapter, "An Approach to Style," extends the scope of the book to include advice on writing that goes beyond mere correctness toward distinction in English style.

Laugh with Barney

The teacher decided the students in her class should write a girl or boy in a foreign country and little Willie was handed the name of a girl from Holland for his pen pal.

That night he shocked his mother by saying, "Guess what, Mom, I got a girl in Dutch."

* * *

The honeymoon is over when the wife complains about the noise her husband makes while he's fixing his own breakfast.

* * *

She: "Did anyone ever tell you how wonderful you are?"
He: "No, I don't believe they ever did."
She: "Then where'd you get the idea?"

* * *

Company president to Executive Board: "... and all those opposed will so signify by saying 'I resign'."

* * *

This is something
That isn't so funny:
To have too much month
At the end of the money.

* * *

"I caught my boy friend necking."
"I caught mine the same way."

* * *

Only one man in a thousand is a leader of men. The other 999 are followers of women ...

"Darling," said the bride at their first breakfast, "I have a confession to make. When you make love to me, and I begin to breathe heavily, I suffer from asthma."

"Thank heaven!" exclaimed the groom. "I thought you were hissing me."

* * *

Sign on the wall of an oil company's leasing department:

"Don't start any vast projects with half vast ideas."

* * *

Once upon a time there were three bears . . . the Papa Bear, Mamma Bear and Baby Bear. Papa and Baby sat down for their porridge and discovered their bowls empty.

"Somebody ate my porridge," bellowed Papa Bear.

"Somebody ate my porridge, too," cried Baby Bear.

"Oh, shut up!" snapped Mamma Bear, "I haven't even served it yet!"

PROPERTY MANAGEMENT — Former drilling contractor and oil producer that has recently sold out is interested in making contact with an individual, group or company to manage and supervise their oil and gas operations, domestic or foreign. Location immaterial.

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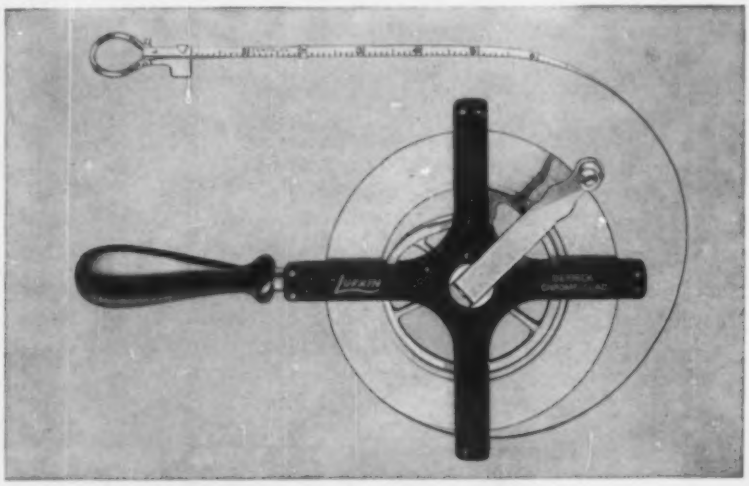

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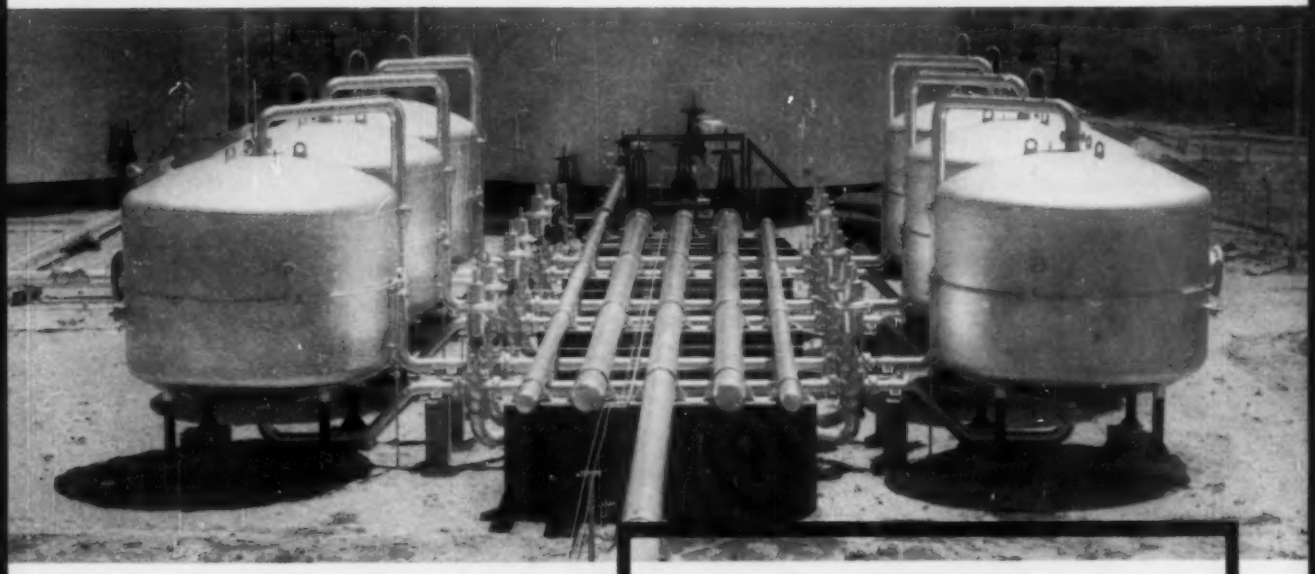
for backwashing from 1 to 10 filters in sequence



Stop wasting power and water by backwashing filters haphazardly. National's Model BFP-100 Automatic Backwash Programmer removes the human error from backwashing and at the same time provides considerable savings in labor, water and power.

The Programmer is actuated by a differential pressure switch which senses the difference in pressure across the filter bed. The length of backwash can be readily changed by changing the setting of the Programmer Timer. The Programmer can be operated automatically or manually, and individual filters can be by-passed.

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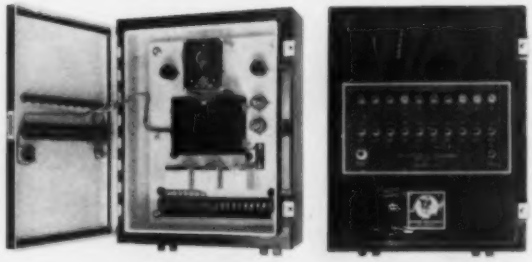

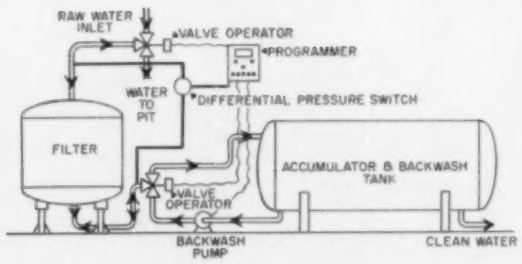

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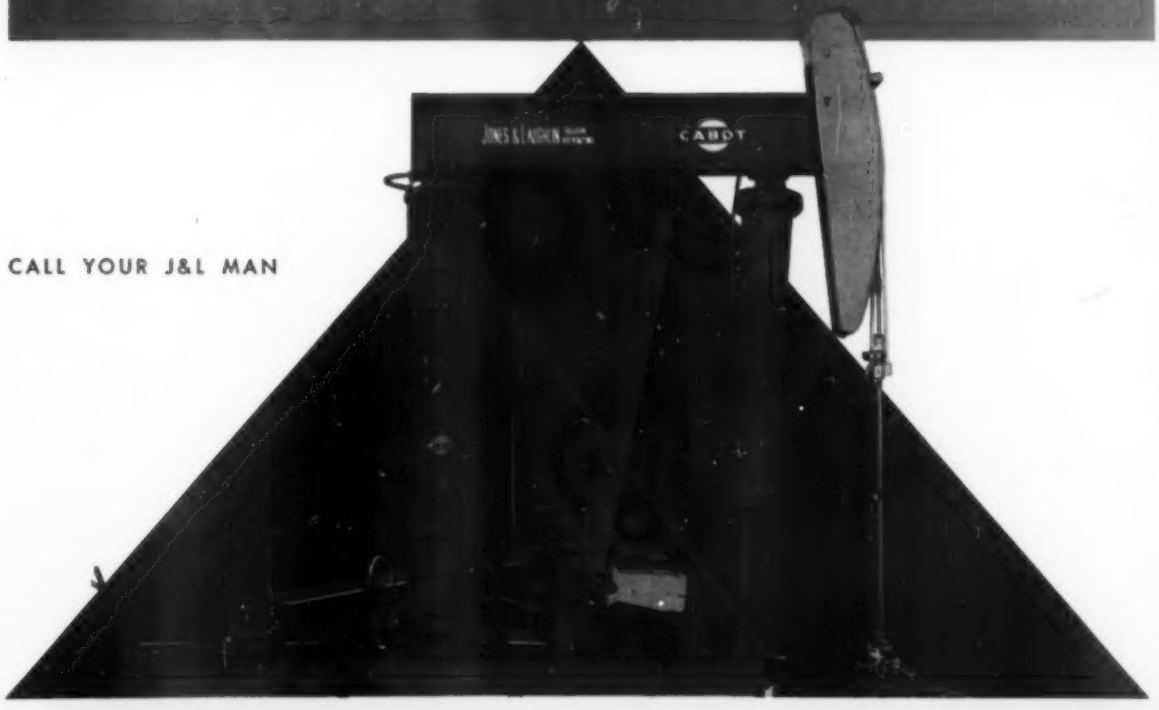

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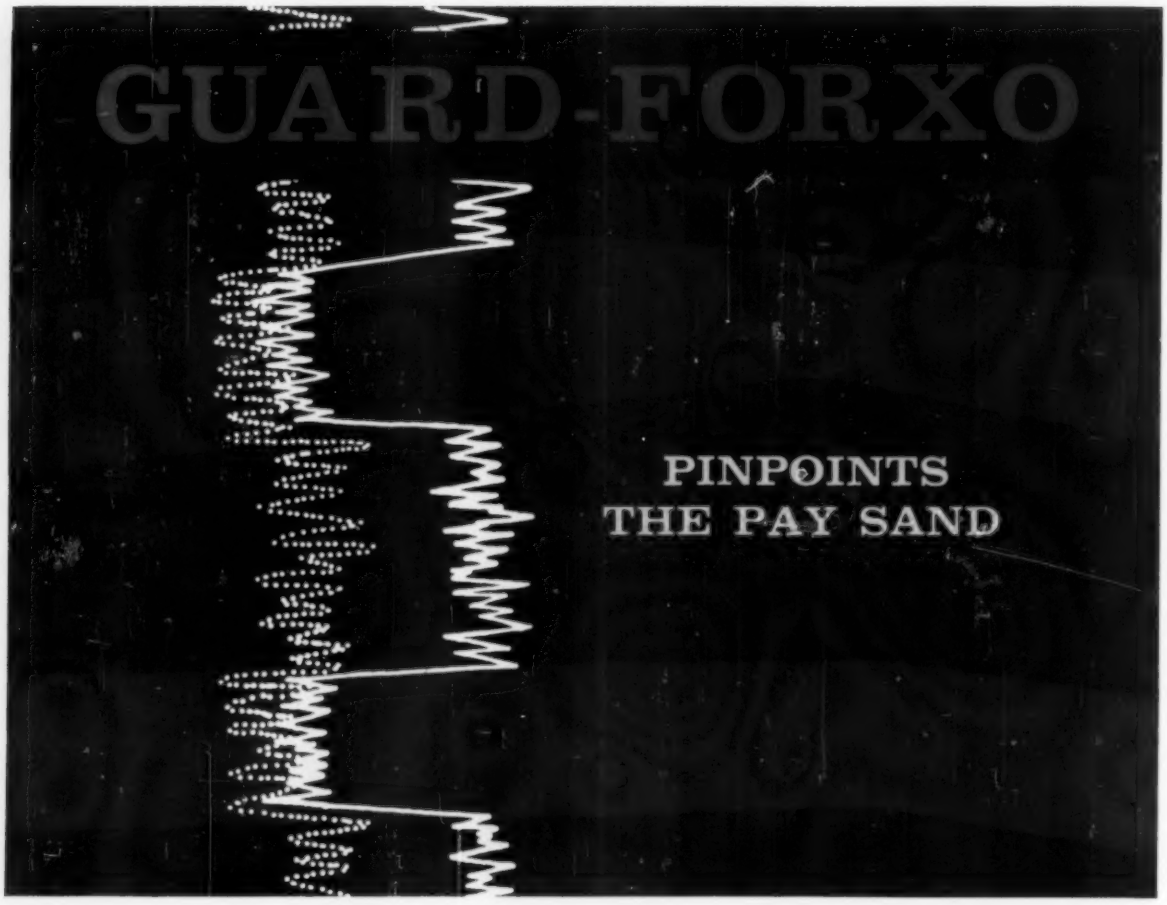

Welex's Guard-FoRxo log makes finding oil easier. If there is a pay sand present, the Guard-FoRxo pinpoints it with precision accuracy. Guesswork and complex computations are minimized. The Guard Log reads the uninvaded zone; the FoRxo measures the flushed zone. A comparison of the two curves results in a positive evaluation of the well, particularly in difficult-to-analyze wells where formation and mud resistivities are similar. Thin beds, shaly sands and rapid lithological changes are easy to analyze with the Guard-FoRxo combination.

No other logging device in the field can record vertical changes in lithology as well as the FoRxo log. No other combination of logs can pinpoint pay sands as accurately as the Welex Guard-FoRxo, particularly where the formation resistivity is similar to the resistivity of the mud.

This is another Welex Production Guide to help the oil man make his own decision with confidence. Contact your nearest Welex representative and let the complete wireline service company give you the finest service in the field today. Call Welex and be sure.

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Of Things To Come . . . In Oil

IMPORTS OF OIL-FIELD STEEL WILL CONTINUE even after the U. S. mills are back in full production following the steel strike. Purchasers who have had to look to foreign suppliers for steel as a result of the strike have set up the machinery for importing the foreign products and some of them will find the new sources continuingly attractive. Also, in some cases, purchasers of tubular goods have had to make relatively long-term agreements with the foreign mills covering orders and shipments for some time to come.

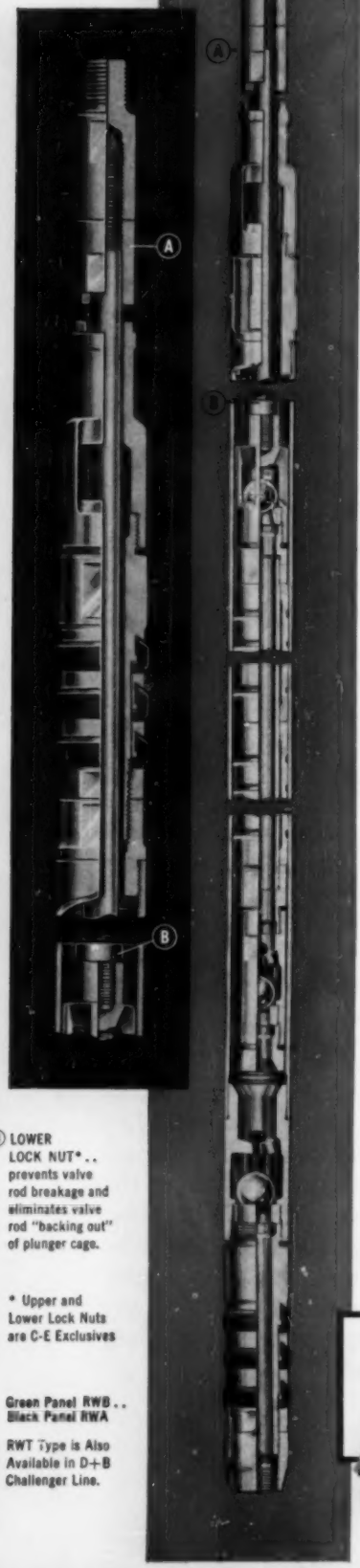
CANADIAN PETROLEUM SURPLUSES WILL DISAPPEAR as the use of petroleum products in North America doubles in the next 15 years. This is the opinion of Lloyd K. Turner, vice president of Westcoast Transmission. He believes that near future development of British Columbia's petroleum resources will result in a new oil pipeline linking the Peace River fields with Vancouver. He says that 1960 will be the busiest in drilling and geophysical work in the history of the north. Eighty wells have been planned at an outlay of $40,000,000 in B. C. alone. In the Yukon and Northwest Territories more wells are going down.

TEXAS' PRODUCTION WILL INCREASE IN 1960 after nine years of declining production. The reversal in the downward trend was started by the first increase in production allowable in five months when the Texas Railroad Commission boosted producing days from 9 to 10 for the month of December. Texas producers have borne the major part of the job of reducing stock surpluses and have, in turn, lost a substantial part of their market to producers in other states. The Texas producers are now ready to reclaim their share of the market, as evidenced by the fact that most of the major oil companies appearing before the Railroad Commission requested the increase in allowable to 10 days for December. Only three companies voted to maintain the 9-day level, and one company hoped for an increase to 11 days.

KEEP YOUR EYE ON THE NEW ENGINE developed by Curtiss-Wright and Nsu Werke of West Germany. The developers claim that they have produced a light, cheap, efficient internal combustion engine with only two moving parts, combining the best features of the reciprocating piston engine and the gas turbine engine. Production is expected this year with models ranging from 100 to 700 hp to be available for cars, boats, planes, or industrial uses. The engine requires no valves, springs, camshafts, connecting rods, or any other similar parts required in a reciprocating piston engine. Only moving parts are the rotor and the crankshaft.

It takes only one line
to pump all medium to deep wells

CONTINENTAL-EMSCO D+B CHALLENGER PUMPS



Ⓐ **UPPER LOCK NUT*.. prevents breakage of valve rod and eliminates unscrewing.**

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* Upper and Lower Lock Nuts are C-E Exclusives

Green Panel RWB.. Black Panel RWA

RWT Type is Also Available in D+B Challenger Line.

Various metals, pump types and pump combinations give *extra flexibility* to D+B Challenger pumps. Interchangeability of their API parts cuts inventory costs. Types are available for all well conditions .. crooked or slant holes .. medium deep to wells over 7,000′. Challenger pumps can be assembled to pump stripper wells, sandy or gaseous fluids. Many corrosive resisting plunger-barrel tube combinations and special cages, fittings and balls and seats can be selected to handle sweet, sour or oxygen corrosion. Special pump combinations to provide extra volume, pump extremely gaseous fluids and meet other well peculiarities can be assembled from standard Challenger pump parts with the use of only a few special parts.

Special Features

VALVE ROD COUPLING AND WING LOCK NUT allow precise spacing of traveling and standing valve for maximum pump efficiency.

PLUNGERS are made of various corrosion resisting metals. They are interchangeable between all types of Challenger pumps and may be switched *end for end* within pumps for longer wear. Plunger sections may be replaced economically after long and hard usage.

ARMORED CAGES are precision machined and given special heat treatments. Ball guides are treated to an extreme hardness to resist wear and assure long life. Outside diameter of body of the cage is given another special heat treatment to insure toughness and durability. C-E's Armored Cages are standard in the make-up of the Challenger pump.

Put D+B Challenger pumps
to work in your wells.

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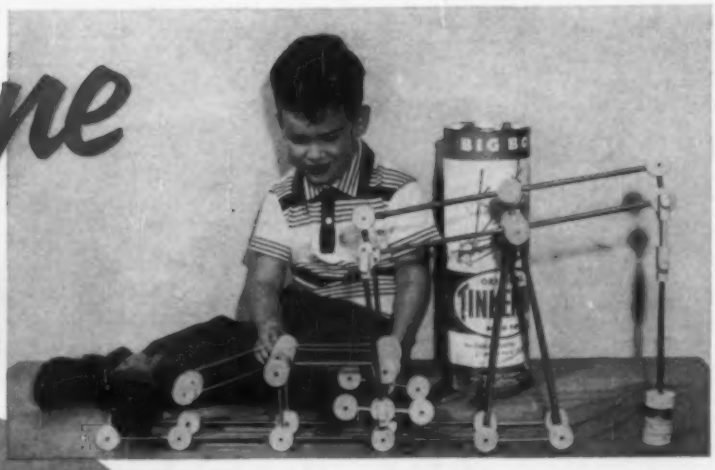
CAN BUILD A PUMPING UNIT



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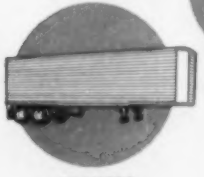

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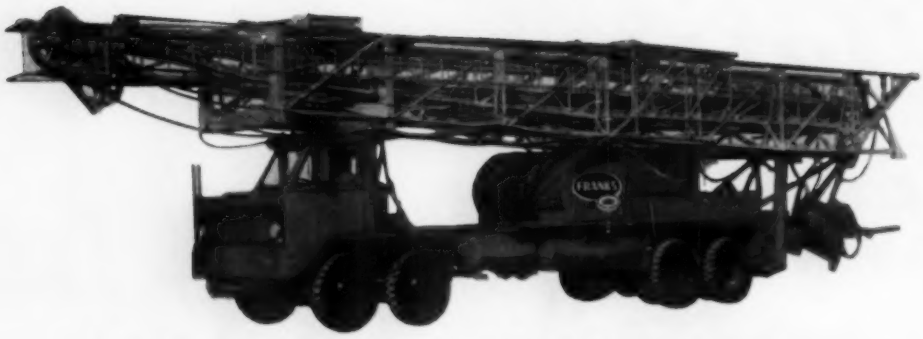
Explorer Rocket



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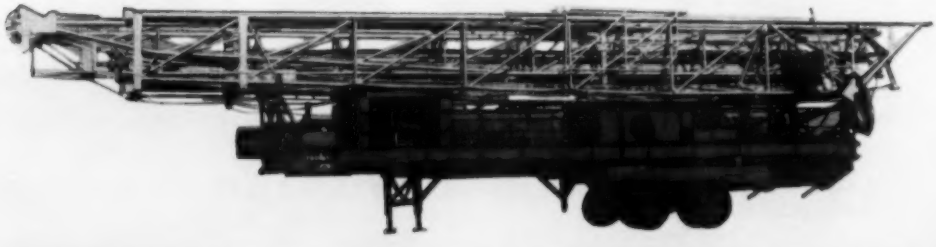
Explorer Cruiser

UNITS IN THE FIELD...

Clipper

Comet

BUT NOT DUPLICATED



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Now, this **difference** is what keeps the Franks Explorer ahead of the pack. It's the difference which makes superintendents prefer Franks units on their jobs. It's the difference you feel in your pocketbook when you trade it in. The higher resale value of Franks Explorers speaks louder of this difference than any words we can dream up.

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Awareness of this fact is the reason for the addition to the famous craftsmanship quality line of Ajax Engines of this new intermediate 80 Usable horsepower unit.

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Simple but massive construction for easy low cost maintenance and long life — rugged special clutch for limited attendance — thermo-syphon cooling — are just a few of the full dollar value Ajax features . . .

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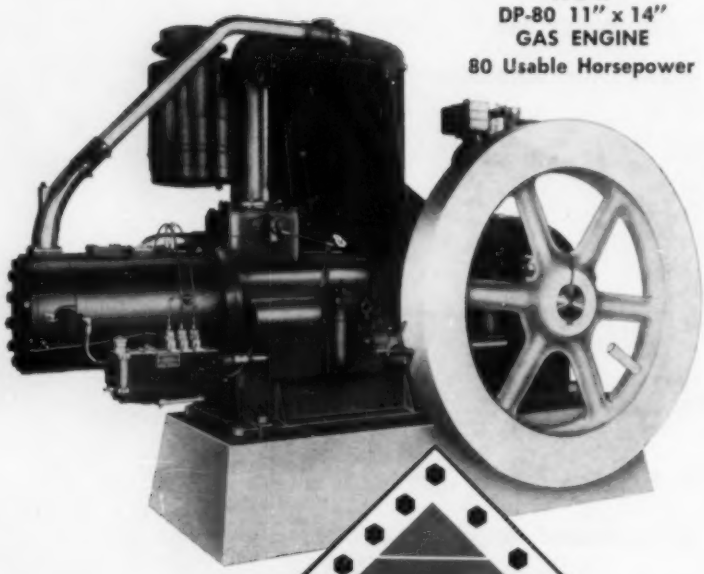

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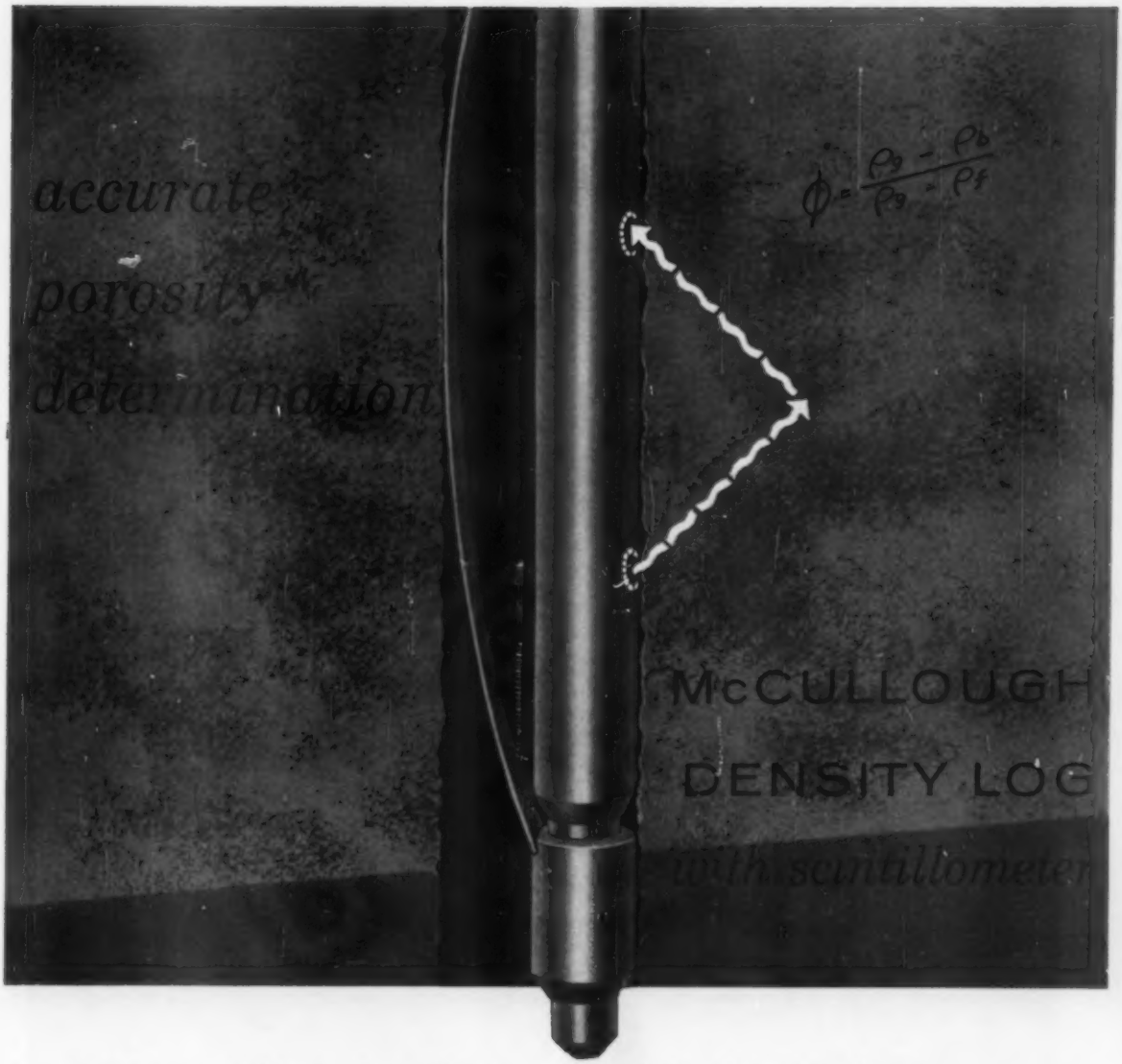

A new advancement in the field of nuclear well logging – McCullough's Density Log accurately measures the bulk density of formations. This rock density is of prime importance in the interpretation of geophysical data. Where grain density values are known, porosity can be determined with accuracy.

The McCullough Density Logger is the only tool of its type that utilizes collimation, the Scintillometer and an energy or pulse height discriminator. By this method, a beam of gamma rays is directed into the formation by the source collimator and back-scattered gamma rays are accepted by the Scintillometer collimator. The discriminator is adjusted for recording gamma rays in the energy band that reflects deep penetration. The numerical intensity of these gamma rays is directly related to the density of the formation.

Check these important features:

- Accurately calibrated in the field with a calibration block of known density.
- Absolute zero is recorded on each log and a linear count scale enables the graphic conversion of counts per second to bulk density for logs run in any well.
- Bulk density, with the grain density of the formation minerals taken into consideration, is in turn graphically converted to accurate porosity values for various types of lithology.
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TWO RIGS total
72,000 HOURS
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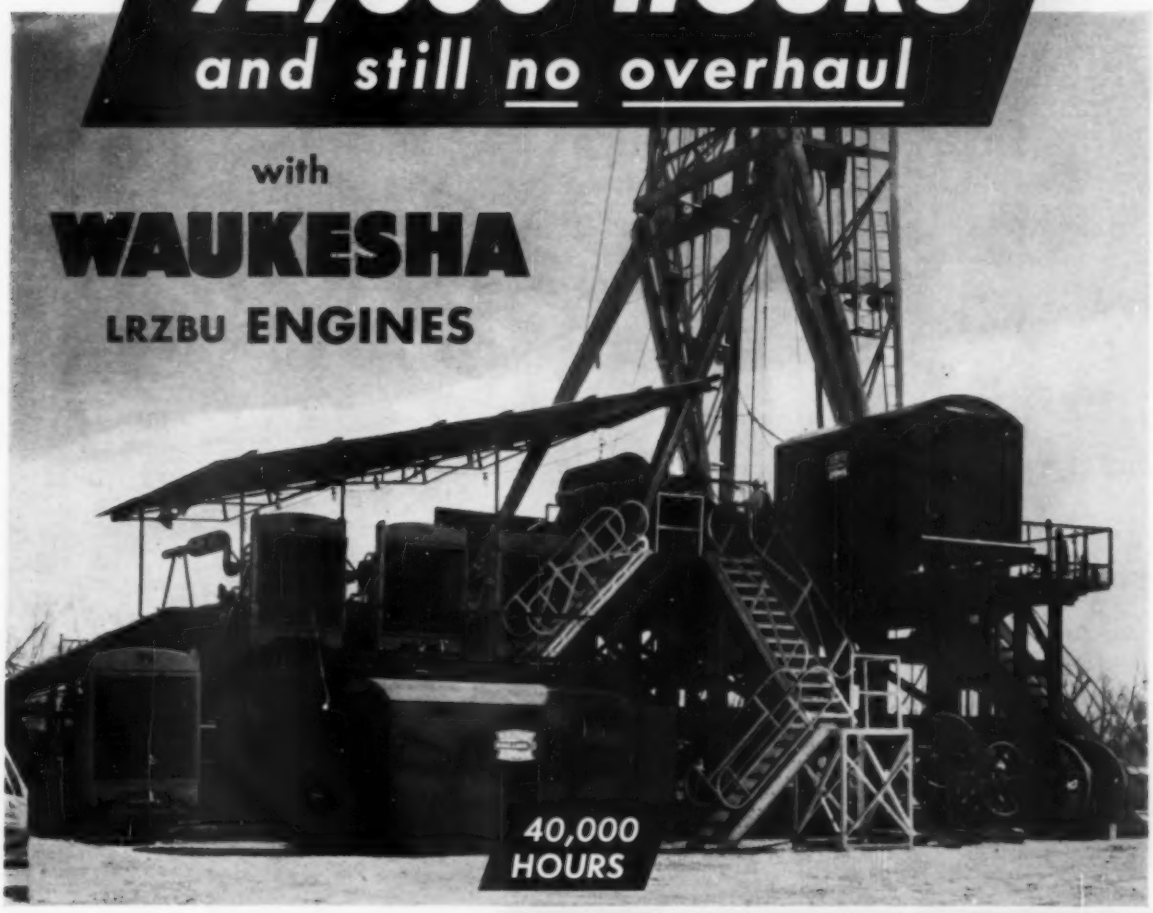
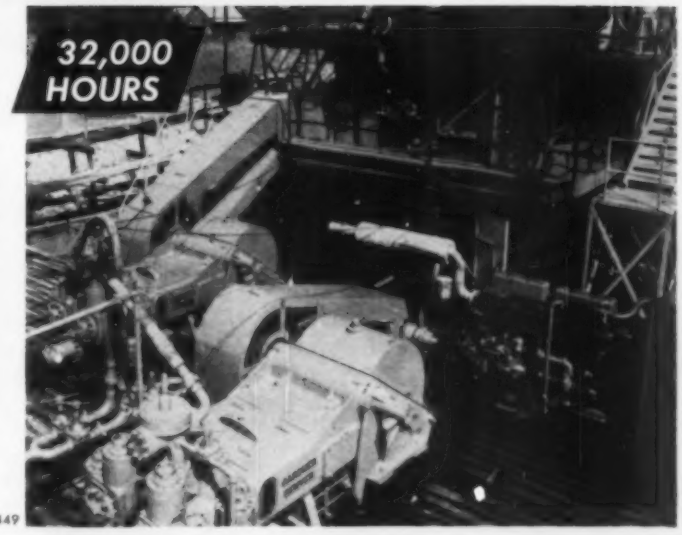
WAUKESHA
LRZBU ENGINES



Two FRED WILSON DRILLING CO. rigs shown operate in southern Louisiana. Rig 12 has four and Rig 9 has three Waukesha gas power units, Model LRZBU, six cyl., 9⅛-in. bore x 8½-in. stroke, 3520 cu. in. displ. Rig 12 (above) has 40,000 hours service; Rig 9 (right) 32,000 hours. No engine has had any overhaul, and practically no repairs, reports Mr. Fred Wilson . . . these are just some reasons why his equipment is 100% Waukesha powered. He operates six rigs (two each of National 110, 80B and 55 sizes) and sixteen Waukesha LRZBU; three LRO; one each NKU, WAKU, 145-GKU; and several XAHU power units. Send for Bulletins.



449

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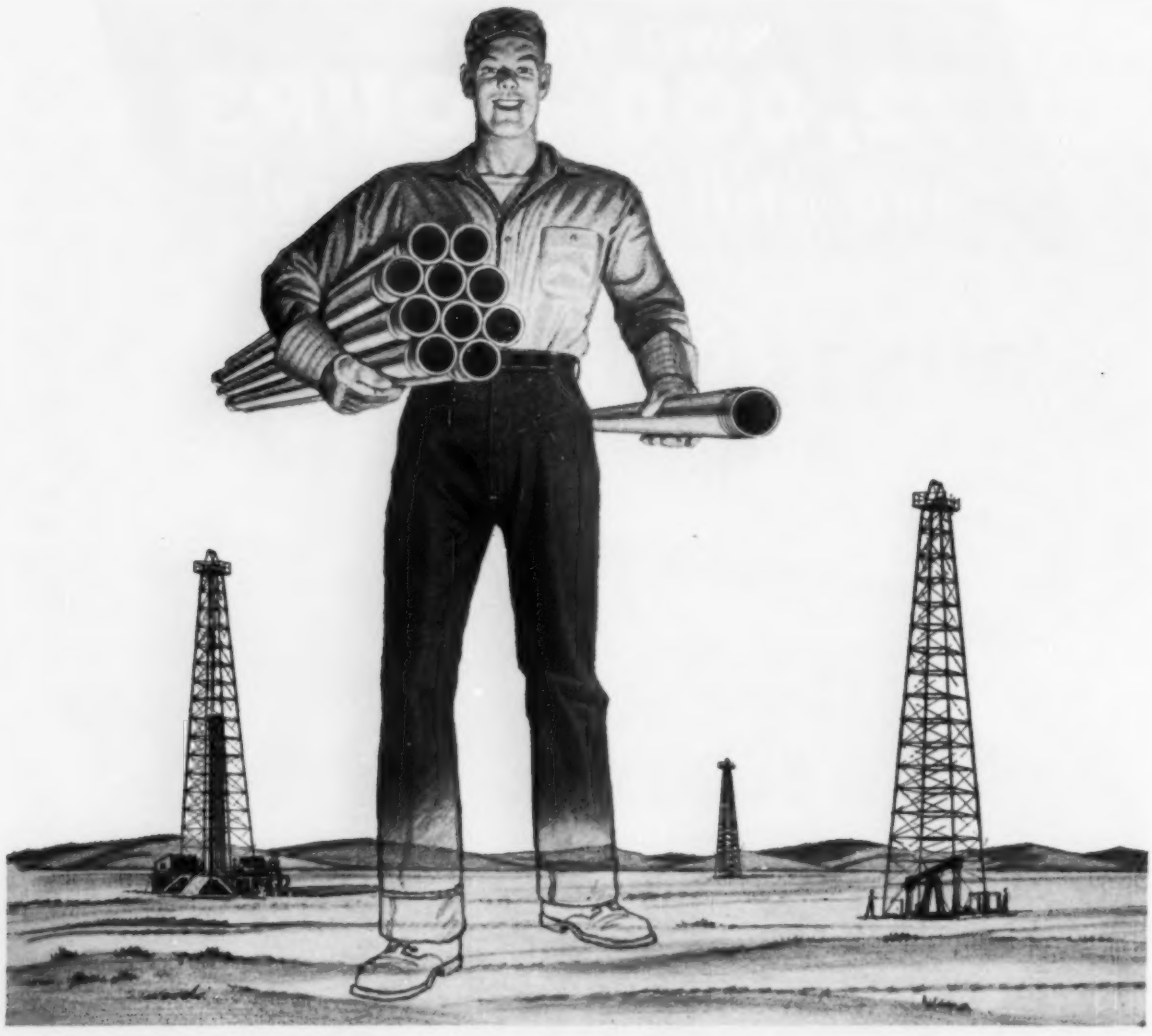

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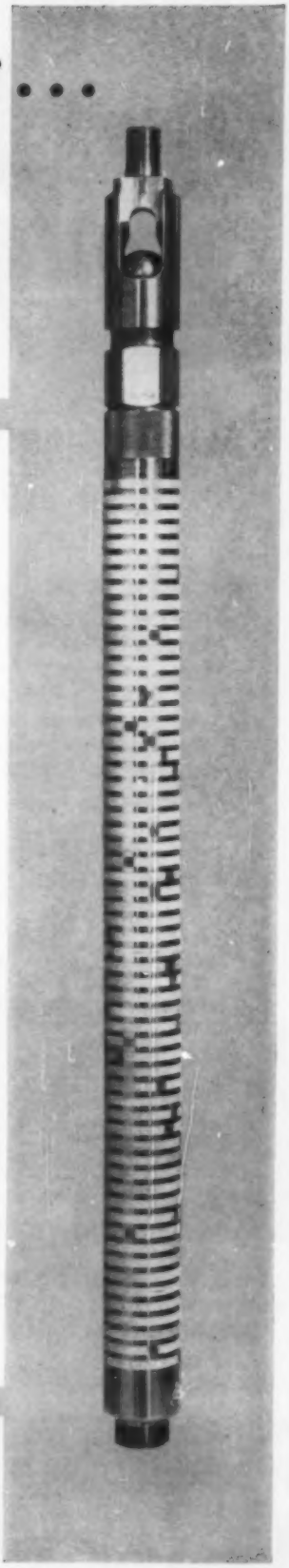

The Martin Idea...

for getting away from this trouble has always been to make use of the best available materials — *Natural Rubber* for the key material in plunger rings; *Synthetic Rubber* for the key material in resilient ball guides for cages.

The accurately grooved and drilled metal body of **The Martin Plunger** does not touch the barrel. Only the resilient rubber and duck rings contact the barrel. This material — with its great natural resistance to abrasion as well as its slipperyness-when-wet — has a much slower wearing action on the barrel. Most often your barrel will not need replacing. These rings have an amazing ability to take the kind of abuse that goes with oil well pumping, and this means longer runs. Plunger cost is reduced because replacing the rings costs only about one fourth as much as a new plunger, and this saving is, of course, added to the barrel saving and longer runs.

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The Martin Rubber Guide Cage protects the ball from all metal contact except when it rests upon its seat. The ball is protected to such an extent that ball and seat life is usually doubled. The synthetic ball guide and stop cannot beat out because of its resilience. Its life is therefore much greater than any metal and you get this longer cage life in addition to better ball and seat life. The two guides are easily replaced when the occasion does arise.

No real capital outlay is required to get these benefits because the cost of Martin Plungers and Martin Cages is very much the same as you are now spending for replacements — sometimes less.

All regular or stroke-thru ROD PUMPS and TUBING PUMPS can be equipped with Martin Plungers. Martin Rubber Guide Cages are made in all sizes and styles. Write for our catalog No. 4; also see Composite catalog for 1956-57.

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Here are the FACTS . . . COMPARE for yourself!

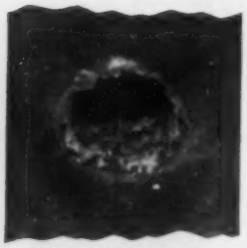
PGAC's new 4" ATLAS-JET charges were recently test-fired in a standard flow lab under simulated subsurface conditions of 1500 p.s.i. at 180°F., into targets with ⅜" steel face-plates, ¾" Hydromite, and 15" deep Berea Sandstone (not cement!) confined in 4½" drill pipe, at stand-offs of 0" – ½" – 1" and 2" in fluid. Well Flow Index for all tests: 1.5 min. to 1.7 max.

The unretouched photos below show a representative test with ½" s.o., the results of which far surpass the published data for all competitive guns. ATLAS-JET data . . .

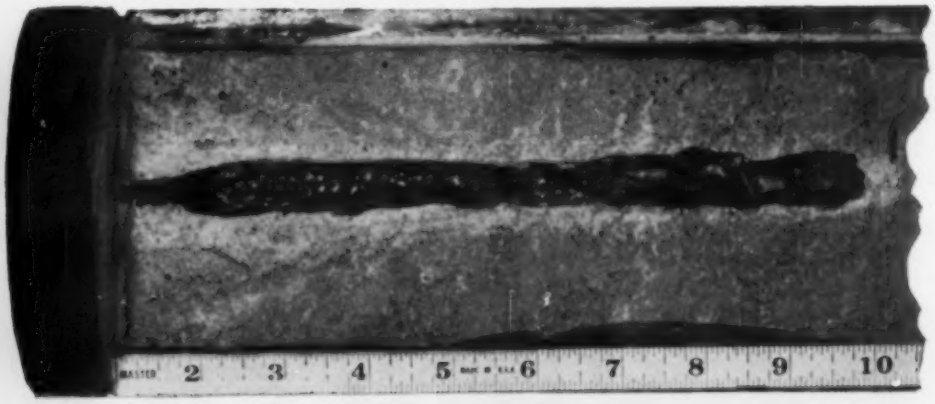
WELL FLOW INDEX	**1.6**
CLEAN HOLE DEPTH	**10"**
HOLE DIAMETER	**0.60"**

These tests were conducted independently of PGAC, with all targets and lab flow data complying with the proposed API standards for perforator evaluation.

Upon request, PGAC field engineers will gladly show you the complete test data – proof of the superiority of the new ATLAS-JET charges now available for 4" and 5" o.d. jet guns.



Actual-size photo of entrance hole through face-plate of test at right



Test result with ½" s.o. in fluid: W.F.I. 1.6; Probe Depth 10"; Hole Diam. 0.60"

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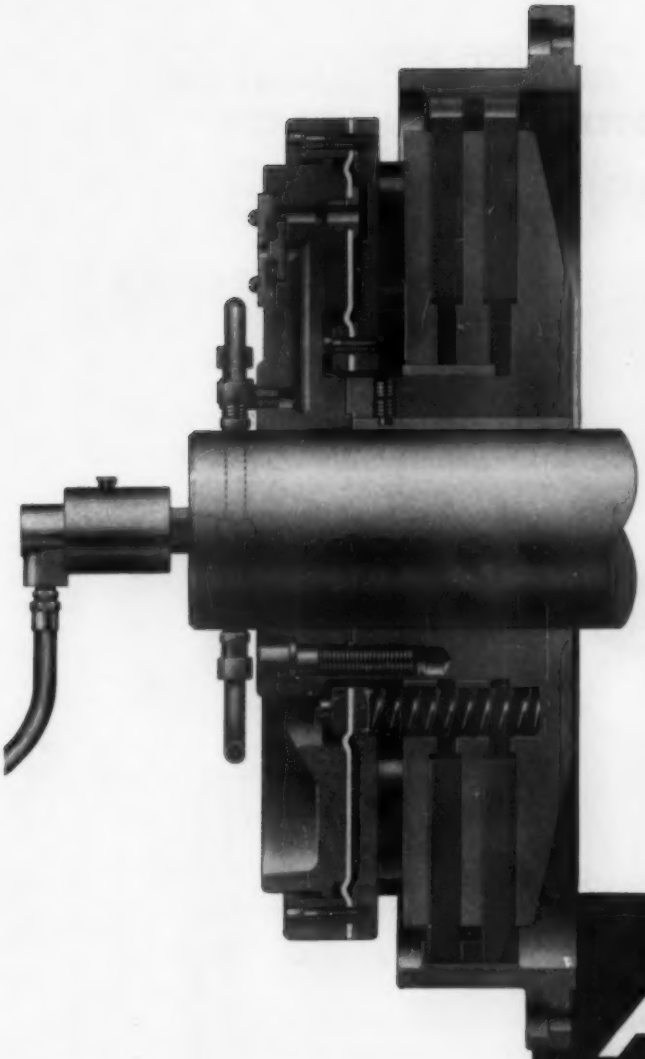

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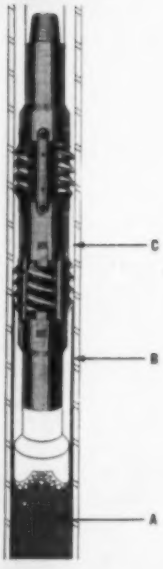

A — Cement to be drilled out.
B — This thin cement sheath, which remains after the bit has passed, often interferes with future operations.
C — Cement sheath and ALL other obstructions removed by the Baker ROTO-Vert Casing Scraper. The vital I.D. of the casing is left clean and smooth, safe for all future down-hole operations.

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Thousands of runs have proved the Baker ROTO-VERT Casing Scraper to be both positive and safe in cleaning up casing I. D. easily and at low cost.

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BAKER OIL TOOLS, INC. HOUSTON LOS ANGELES NEW YORK

Outlook for 1960 . . .

ECONOMY FROM IMPROVED TECHNIQUES

Necessity forces optimum application of drilling, completion and production methods for greater efficiency to maintain profit margin in the face of rising costs

A DIVISION drilling superintendent for a major production company estimates that his company saved $6,000,000 during the past year through improved drilling practices along the Gulf Coast.

Economy through improved techniques is the watchword throughout oil regions of the world, and there have been many improvements. With today's competition, only developments that show definite profit potential will be selected and used.

Main objective of one major oil company research center is to optimize rotary drilling techniques in effect now. They seek more accurate and precise data on the factors encountered with conventional equipment rather than concentrating on developing revolutionary new concepts.

Under development is a mobile electronically-equipped rotary drilling rig that will pick up simultaneously all drilling variables and record this data to give exact engineering knowledge.

Selective automation of equipment, such as pipehandling of the drill string on return trips, is being sought.

Dual objective is to put drilling on a scientific basis and reduce the expensive trained manpower needed to drill a well. Safety is another factor that is improved by these studies.

Factors giving overall drilling improvement:

1. Better exploration and subsurface work has improved discovery percentage and field development practices.
2. Wider well spacing allows drilling fewer wells and better conservation measures. This requires cooperation between oil companies and the state regulatory agencies to solve their mutual problems.
3. Utilization of wells has increased through use of multiple stage and permanent-type completions. This gives maximum drainage efficiency from each well with a minimum of maintenance and workover expense.

Drilling costs have been reduced by optimum drilling techniques to obtain efficiency.

Each area of the world has different drilling problems, and this should be considered more than it is in developing equipment, a division superintendent stated.

"We need techniques developed to improve drilling in a particular area rather than have techniques designed as a solution to problems all over the world."

This approach applies optimum drilling practices under actual field conditions.

"We may have lost circulation so badly that we can't use hydraulics, for example," he added. "If field conditions would permit, we would always put maximum bit horsepower working on the bottom of the hole using certain desired annular velocities designed to remove bit cuttings at whatever maximum drilling rate we are able to achieve."

There hasn't been a single phase of our drilling program that we couldn't revise to fit particular problems in particular fields. "Costs have been reduced 30-40 percent using techniques designed for optimum efficiency in proved fields over five years old."

Slim-hole or tubingless completion with improved drilling techniques will often result in much marginal production being profitable today that wasn't profitable five years ago.

"Cost for a complete well can be reduced from $50,000 to $30,000 or less," he concluded.

Another method of reducing drilling costs is improved equipment. Rigs are smaller but have more horsepower, flexibility, and portability.

Tremendous strides have been made in the use of muds. Oil base muds and asphaltic base muds are kept stable under salt water flows and gas flows. They are maintained in good condition with desanders, centrifuges, degassers, and shale shakers.

Plastic flow diagrams which give pre-calculated optimum consistencies are being used for continual checks on mud condition.

Catastrophic losses from blowouts are being prevented by recently introduced warning devices. Pit levelers, for example, give instantaneous warning before high pressures can replace mud in the annular column to the critical point. The device measures the amount of fluid going in and out of the hole. This gives an immediate check for blowout danger or fluid loss into formation.

In production, getting more oil out of the hole is receiving proportionately greater attention as the dollar-cost of finding new oil increases. Researchers are making it more economical to recover oil already found, and reservoirs that had been considered exhausted are being revived.

Newly developed fields are being equipped with gas injection, water injection, and other systems to improve recovery during primary production stages.

Most techniques are not new ideas but simply developments of old ideas brought about by applying new materials that make them practical.

Drilling

Hydraulics. Greatest area of change is in high pressure hydraulics for circulation while drilling. Operators are using maximum horsepower at the bit, and the trend is toward

larger pumps or coupling two pumps together for greater output.

They have found that good hydraulics multiply drilling rates and are using calculated curves to determine optimum pressures.

Slim-hole drilling. There is generally a trend toward using compact equipment in smaller diameter holes, although opinion differs as to just what is "slim-hole" drilling. Savings are obtained in equipment and the materials used to drill the holes.

During the past year, much needed equipment was put on the market to facilitate this technique. Most has been scaled-down conventional equipment.

A step-type bit developed for this purpose has rings which are widest at the bottom and graduate in steps to smaller diameters at the shank. It is a bearingless, coneless bit something like a drag bit and has been tested in California drilling.

Drilling automation. "Probably automation in drilling equipment will be a gradual, piece by piece evolution rather than an overnight change-over," a top executive for one of the largest equipment manufacturers stated.

Fully-automated rigs have been operated experimentally, but do not promise immediate large-scale entry on the drilling scene.

Jet-bit deflection. Directional drilling rates have been stepped up considerably with reduced control problems when tricone jet bits with all but one jet restricted have been used in the softer formations. It also saved time in drilling surface holes.

The technique eliminates the need for costly extra equipment such as whipstock, knuckle joint, and spud bit.

The single open jet spews a stream to help break formations, erodes the well bore on sides and bottom.

Air and gas drilling. Though still in its infancy, air and gas drilling has been perfected fairly well. It has been limited thus far to areas without seepage problems that would allow water to infiltrate into the hole, but new developments combat this restriction.

Dry chemicals fight weeping zones and foaming agents aid in mist drilling to keep formation water out of the hole. An inflatable packer has been devised that serves as a water shut-off while squeezing treating chemicals into the hole, and it deflates after the treatment is completed.

A small turbine added to an air compressor being used on a rig is reported to triple air rate, which also aids in shutting out water.

Desirability of air drilling, besides eliminating mud costs, includes longer bit life since air has been found to be the best media for bit operation.

Air hammer drill. In some formations, drilling rate has been improved up to three times by the air hammer drill, which is now being manufactured. A practical mud-operated hammer drill still hasn't been developed.

The rotary drill string has some of the same effect when operating, as there is a continual up-and-down movement of the string due to flexibility of the column, researchers have found.

Bits. Opinions vary on what is the optimum technique to operate the bit.

One researcher for a major oil company says his company is having best results from starting with comparatively light bit loads when the bit is new, then progressively increasing the load as the bit becomes dull.

A general operating trend is to pour on weight while drilling until the bit almost breaks from the strain.

Sealed-bearing bits are an attempt to increase life in formations that wear the bearings before dulling the teeth. They are being manufactured for use in chert, which is one of the more suitable applications.

Developed from a similar bit introduced in the mid-1920's this new development is possible because of improved steels and sealing materials.

A four-cone rock bit has been recently introduced, designed for better balance and smoother operation.

Muds. Extreme pressure (e.p.) drilling muds have been effective, but more field usage must prove them better than oil emulsion muds for increased bit life.

They are expected to give better results where high temperatures are encountered.

A new technique involves the injection of air into the mud column at a point near the bottom of the hole, using a special injection pipe. This has the effect of lightening the column.

There is increased use of fluid-loss additives in drilling muds to maintain uniform consistency and minimize formation contamination by preventing fluid from escaping into the reservoir matrix.

More attention has been given to selecting a special completion mud or conditioning the drilling fluid before bringing in the well. This has resulted in more successful completions.

Logging. Oilmen are now closer to direct oil-finding means with the introduction of new logging devices, including those that give readings from gamma rays bombarding the formation. With several techniques combined in a single instrument, they can get a systematic interpretation of pay zones as they are encountered.

Economy results also since drillers may not have to halt operations to cut cores anymore.

Electric-powered rigs. Increasing in use are electric-powered drilling rigs that offer portability and flexibility.

Engines at ground level drive generators and mud pumps, and the drawworks operates electrically.

Some portable electric rigs are designed for movement by airplane, and their flexibility is demonstrated by a single engine driving the generator that provides power in several areas.

Tubular goods. Extreme temperature and pressure requirements have necessitated the development of better tubular goods.

Steel stands temperature up to the point at which it was initially set from the molten steel, and continually deeper drilling trends have resulted in steel that has been set at very high temperature.

Unique drilling methods. Turbodrills, which are shelved at present, have shown themselves to be superior mechanisms for driving drill strings, but the bits wear out too fast.

Suggested methods that may overcome this difficulty were more study toward the application of hydraulics while drilling and the use of sealed bearing bits with the tool.

Since high return velocity results from using the tool, bottom-hole pressures compress the formation. A slower velocity and greater volume of mud with different type turbine wheel may produce usable results.

High velocity flame drilling has given promising results in shothole drilling and mining. It may have oilfield applications, also.

Explosion drilling has thus far not proved economical. The Soviets have been experimenting with circulating charges to the bottom of the hole to provide the explosion. Nothing practical has developed from nuclear explosions, either, but the government is continuing tests that may eventually prove useful.

Progress continues on the Mohole project undertaken by the government, in which an attempt will be made to penetrate the earths outer crust. Drilling will be done from a floating vessel, which has been a successful technique employed by offshore drillers.

Some oilmen would like to see the test conducted as a

probe for hydrocarbons in extreme depths of the continental shelf, which they feel would be beneficial in guiding development of the offshore potential.

Completions

Perforating. Latest development in perforating is a self-aiming gun that uses a nuclear detector instead of pre-positioned mandrels to orient it away from other tubing strings in multiple completions.

Hydraulic perforating was introduced last year to perforate casing without the use of explosives, enlarge well bore diameters, and remove scale or other deposits from the face of producing formations.

Multiple completions. Multiple tubingless completions with as many as four strings are being used successfully. One major company is making installations using 2½-in. tubing strings.

Completion mud. It must remain stable throughout the sequence of operations occurring during the testing and completion of the well. It will not settle out after standing for long periods, and must inhibit corrosion.

It must meet the requirements of reservoir technology and be within economic limits prescribed by the potential productivity of the well. Field results have shown that chemical emulsion muds, which employ sodium and calcium salts to retard shale hydration, offer excellent protection to the producing formation.

Reduction of mud weight to minimum safe operating limits has been found to reduce the tendency of mud solids to penetrate the producing formation.

When the drilling mud is used for completion, special treating techniques are being employed.

Completion muds are discussed fully in another article in this issue. (See page B-22.)

Production

Lease automatic custody transfer. Longer periods of operation without manual check, with better and more accurate accumulation of data, have resulted from the rapid installation of lease automatic custody transfer systems.

The systems give complete data, including average gravity, average temperature, and the average bottom sediments and water readings accurately accumulated and stored over a monthly period. This also facilitates better accounting records of the operation.

A BS&W monitor gives continuous stream analysis and an accumulated average value over any desired period of time.

A new device located entirely within one of the tanks makes accurate measurement of gravity without any of the intermittent operation now required. Better temperature measurements resulting from improved measuring devices are now possible. A programmer controls readout time and sequence, then makes a printed record of each value.

Labor savings are listed as a big factor in the increasing popularity of LACT systems, and they help provide a quick payout on producing properties.

Automation also is being employed in well testing, and microwave installations form an integral part of automation control. Isolated onshore and offshore leases benefit from the advantages of push-button control where transportation offers difficulty. Most automation is on newly-developed reservoirs of considerable size.

Hydraulic fracturing. Industry-wide acceptance attests to the effectiveness of hydraulic fracturing of formations to stimulate well recovery. Recently, planned fracturing treatment based on accepted engineering procedure has evolved.

Miscible phase displacement. Development continues on an optimum flushing system to obtain sweepout of hydrocarbons that is consistent with the payout and other economies of the system. Combinations of LPG, natural gas, water slugs, and alternate slugs of both of the latter are being tried continually, with good results in many instances.

Research and field studies continue to provide additional knowledge about the performance of miscibility and nonmiscibility to enable engineers to tailor a program for a given reservoir that will have a favorable economic basis.

There are hundreds of processes used, and slug-type injection of miscible, immiscible, and combinations have provided surprisingly good results in many instances.

Thermal recovery. Heat improves the mobility of low gravity crude oil, which is important to producing it effectively. Efforts are being made to get better heat efficiency from the thermal systems, as at present the heat loss into formation is considerable.

Besides increased activity in installing in-situ combustion systems, interest in the older method of heating from the surface, particularly by steam, is growing. Heating by various devices dates back to the last century.

In-situ combustion is still under development, researchers say, and has never really been proved economically. "We have just touched the surface on all of them," a research scientist stated.

Primary factors considered in deciding on an in-situ process are permeability of the reservoir rock and the nature of the displacement mechanism, besides the gravity of the crude.

Results of recent field tests with in-situ combustion indicate oil recoveries of higher than 50 percent in reservoirs considered poor prospects. Heat is created by injecting air into the reservoir and using an igniter to touch off crude in the formation. The process is sometimes reversed when the ignition well is converted to the producing well.

Preplanning the method facilitates the choice of fracturing materials and correct methods necessary to obtain the desired fracture area and corresponding void in the formation.

Waterflooding. Surfactant chemical treated water is the most prominently used system in waterflooding, which is still the most widely-used form of secondary recovery.

More technology of waterflooding is known now than ever before, and the trend is to expand sweep-out efficiencies and automate surface equipment for smoother and more efficient operations.

Economics and payout still dominate the decision as to whether to waterflood or not, but with all of the new aids available its usefulness to the producer continues to spread.

Unique method. A pilot project for gas injection in attic-oil recovery has flowed at top allowable since its injection phase was completed in 1958. Previously, the well had watered out.

Radial faults had developed fully in the formation, but it still contained marginal oil reserves updip in a formation adjacent to a salt dome. This type formation mostly has prolific water drive and pressures remain nearly constant, but wells water out before updip oil is recovered.

With the poor structural control of attic regions and marginal size, it was impractical to attempt drilling. The gas was injected into the highest well after all recoverable downdip oil had been produced and is now giving satisfactory production.

Oil shale and tar sands. The government should subsidize development of these immense reserves for security reasons, a researcher stated. Companies have conducted experiments on the feasibility of commercial production, but this area requires much more effort.

The Soviets are producing impermeable oil-bearing rock using mining methods. ★ ★ ★

MODERN WELL COMPLETION SERIES

PART 3

Conditioning Mud for Well Completion

Mud used should remain stable during testing and completion, offer maximum protection to the reservoir, and stay within economic limits

Robert W. Ruhe, Jr. *Staff Service Engineer, Magnet Cove Barium Corporation, Houston, Texas*

THE PRINCIPLE REASON for drilling a well is to find oil, gas, or both hydrocarbons. The drilling mud allows this to be accomplished with minimum risk since the proper selection and conditioning of the mud improves the chances of obtaining good geological information, a good cement job, and better production. A properly conditioned mud results in better sample cuttings; and the correct mud type reduces hole enlargement.

The mud and logging programs should be closely coordinated. Some formations can be damaged by drilling mud or drilling mud filtrate, and certain muds have been found to offer protection to sensitive producing zones.

Selecting Completion Muds

Today, completion muds should be selected on the basis of several considerations. Regardless of whether the drilling mud is used or a special completion mud prepared, the same consideration should be applied.

The completion mud should offer maximum protection to the reservoir. It should remain stable throughout the sequence of operations occurring during the testing and completion of the well. If it is to be left behind a packer, it should remain stable indefinitely so that when it becomes necessary to workover the well, fishing operations will not result from deterioration of the mud.

A completion mud should meet the requirements of reservoir technology and be within the economic limits prescribed by the potential productivity of the well.

Reservoir factors. In selecting a completion mud some knowledge of the reservoir is essential. This may be obtained from previous knowledge of the producing formation, electrical log data, or core data. The lithology and composition of the reservoir rocks should be considered.

Most limestone or dolomite reservoirs are not adversely affected by the type of mud used during completion. Sandstone reservoirs, however, present a different picture. It is extremely important to know whether the sands contain bentonitic clays, either as the cementing or bonding agent or as a contaminant in the form of silt. If these clays are present, the introduction of fresh water as mud filtrate will cause hydration and swelling of the clays into the flow channels. This results in a reduction of the effective porosity and permeability. Thus, the chemical nature of the mud filtrate should be inhibitive so that it prevents clay hydration.

The selection of a completion mud should also be based on a knowledge of the salinity of the formation water and the probable water saturation. In wells which are likely to produce with a water cut, stuck pipe or the inability to run tools and logs to the desired depths can result from severe flocculation, high fluid loss, and the settling of weight material.

Reservoir pressure dictates the mud weight required. The hydrostatic pressure exerted by the mud column should be adequate but not excessive. During drilling operations a differential hydrostatic pressure of 500 to 1000 psi is sometimes specified for safety in blowout prevention. However, during completion operations, a few hundred pounds differential is considered satisfactory.

Bottom hole temperature should be considered for mud selection in completion operations as well as drilling. Muds which might break down or become severely gelled by prolonged standing at high bottom hole temperature should not be used if extensive down-hole operations are planned. Furthermore, these muds should not be considered for leaving behind the packer. Mud stability to temperature is equally as important as adequate hydrostatic pressure in affording protection to the reservoir and the ease with which operations are carried out.

Physical properties of mud. Fluid loss has frequently been blamed for the failure to make a good producing well in potentially high-productivity zones. The assumption is that a water block has been formed or that a portion of the flow channels have been blocked by the swelling of hydratable clay materials present in the formation.

Good tight chemical emulsion muds, which employ sodium and calcium salts to retard shale hydration, offer excellent protection to the producing formation. Oil aids in controlling the fluid loss at practical working values, while the inhibitive environment of the filtrate prevents swelling of any hydratable solids which might be present in the producing formation. Chemical emulsions are formed with surface active materials which offer an additional benefit when dealing with low-pressure formations.

When these emulsions are properly formed, the surface tension of the filtrate approaches that of oil, so that the invasion filtrate is easily removed when the well is placed on production. This may seem to be an insignificant factor but its importance cannot be overemphasized when one considers that it requires the expenditure of three times more energy to displace water with oil than oil with water in a capillary.

Some instances may arise where the productive formations are so extremely sensitive to water-base muds that it may be desirable to complete the well with a mud in which oil is the continuous phase. In such cases the use of invert emulsion (water-in-oil) or oil

base muds have been successful. These muds have little or no API fluid loss, and since the filtrate which does develop is oil, water never comes in contact with the formation. These are usually considered as being special muds because they are not commonly employed in drilling. However, formations which are extremely water sensitive should be drilled with invert emulsion or oil base mud.

Excessive mud weight can cause the penetration of both mud solids and filtrate into the formation. In extreme cases, mud weight can result in the breaking down of the formation and the loss of whole mud into the formation. In either case, mud solids may be deposited within the formation causing considerable damage.

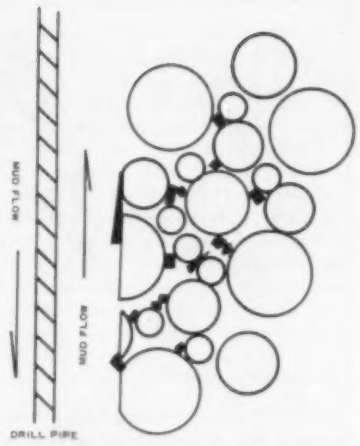
Naturally associated properties are viscosity, gel strength, and mud weight. The viscosity should be sufficient to adequately suspend barite while circulating. The gel strength should be sufficient to prevent settling when static conditions exist in the well, but should not be excessive or it will prevent running and placement of tools, perforating guns, and logs. Lack of sufficient viscosity and gel strength can result in serious loss of mud weight through settling of the barite, and if allowed to occur during prolonged testing operations can result in expensive fishing operations. Abnormally high viscosity and gel strength, on the other hand, can be just as damaging. When the viscosity is high, swabbing becomes a serious problem and could result in a blowout. High gel strength requiring excessive pump pressures can cause lost circulation and breakdown of the producing formation.

The mud used for well completion work where contamination is possible, should tolerate at least salt water and cement. Many times the upsetting effects of these contaminants on various muds can be serious, resulting in high viscosities, gel strength, and fluid loss. In the case of high salt water contamination, virtually complete loss of viscosity and fluid loss control can result.

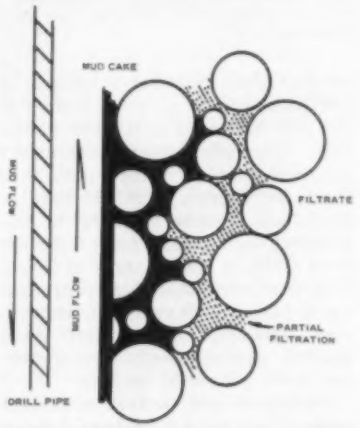
Types and Conditioning

Frequently, drilling muds are also used as the completion fluid, and even when special completion muds are used, they are really specialized drilling muds. There are a number of different types of muds that can be used for completion fluids. Each has a best application, and when used properly, satisfactory results will be obtained.

Low pH muds. These muds are lightly treated low pH (8.0 to 9.5) drilling muds. They depend on the proper balance of colloidal solids, such as bentonite; and chemical treatment with caustic soda, an organic thinner and one of the complex polyphosphates, for fluid loss and viscosity control. They are best applied as low weight muds with the most desirable flow properties occurring at weights which do not exceed 12 to 14 lb per gal.



In initial stages of wall cake formation, solid particles filter out both at the face of the bore hole and within the formation where a restriction small enough to block further penetration of the particle occurs.



Wall cake forms at the face of well bore, there is a zone of particle filtration, and a flushed zone represented by filtrate. Phenomena illustrated must occur with a water base mud before any degree of filtration control can be established in the permeable formation.

Low pH muds of this type have their best application as completion muds in shallow wells where low mud weights are satisfactory and contamination from cement and salt water is not anticipated. The simplicity of treatment of these muds makes their use highly attractive. Conditioning them consists of adjusting the water loss and flow properties with bentonite, caustic soda, and a thinner. If cement is to be drilled with the mud, pretreatment with one of the complex phosphates is generally adequate in overcoming its effects.

Satisfactory performance can be expected from these muds so long as contamination is held at relatively low limits. Because of their simplicity, these muds are very unstable in the presence of contamination. In wells where the testing program calls for a number of zones to be tested and squeezed, or there is a possibility of introducing considerable quantities of salt water into the well, these muds should not be used. They also become severely gelled if left behind the packer for long periods of time after completion.

High pH lime muds. These have been popular for high-weight drilling for many years. Basically these muds are composed of lime; caustic soda; an organic thinner which is usually quebracho; and an organic colloid, starch or CMC, for fluid loss control. Their principle advantages are their ability to retain low viscosity and gel strengths at high mud weights and their excellent stability in the presence of contamination.

Because of their extreme stability, these muds do not often need to be conditioned. However, when conditioning does become necessary, it is usually only a matter of adjusting the lime content and alkalinity with lime, caustic soda, or both; then completing dispersion with an organic thinner.

For many years, these muds served as the only practical muds for deep high pressure drilling. However, high pH lime muds have proved unsatisfactory as completion fluids. With high temperature and sufficient time, lime muds tend to solidify. Quite often, when high pH lime muds are left behind the packer and the well has to be reworked, it is necessary to washover a string of tubing because of the plastic condition of the mud.

Gyp muds. Originally gyp muds were not very effective as drilling muds, they were even less effective as completion muds because of high-flash gel strengths. Recently through the development of thinners which are effective in controlling the gel strengths, gyp muds have become very popular both as drilling and completion muds. At the present time, gyp muds are composed primarily of gypsum, sodium carboxymethylcellulose, (CMC) and an organic thinner. Gyp muds have much the same flow properties, about the same resistance to contamination, and somewhat better stability at high temperature than conventional lime muds because of their low pH, which is 8.5 to 9.5.

Gyp muds do not offer a major conditioning problem. While it is often necessary to reduce the low gravity solids concentration and adjust the viscosity and fluid loss to appropriate values, the chemical balance of the system is easily controlled with gypsum

and thinner. Furthermore, the filtrate calcium should be adjusted between 500 and 800 ppm to prevent premature gelation due to excess calcium effects.

Gyp muds are now being used anywhere conventional lime muds have been used in the past as completion fluids. Generally, satisfactory results can be expected from the use of gyp muds as completion muds. However, it is doubtful whether gyp muds will make good packer fluids. Although they do not undergo cementation reactions at high temperatures, a severe gelation problem will occur with time.

Shale control muds. As the name implies, shale control muds have been developed to control difficult shale drilling problems, principally that of mud-making hydratable shale. These muds have essentially the same physical properties as the gyp muds. They have low viscosity at high weights, good fluid loss control, and stability. They are probably the most inhibitive of the fresh water muds in the prevention of shale swelling and hydration.

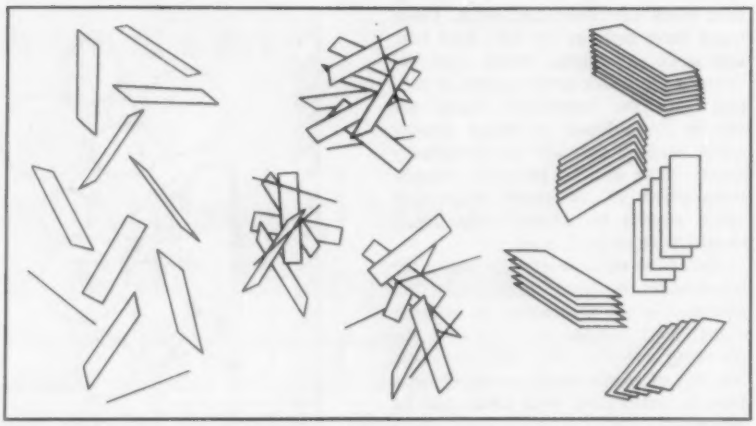
Shale control muds are usually referred to by their trade names. They are maintained and conditioned by additions of premixed sack compounds for control of the chemical and the physical properties. The fluid loss is controlled by additions of starch or CMC. Occasionally minor adjustments of filtrate calcium (400 to 800 ppm) necessitate small additions of soda ash or caustic soda.

Generally, satisfactory results will be obtained when shale control muds are used during completion. These muds probably offer the best protection to water-sensitive formations obtainable with a water base mud. The same resistance to contamination and stability can be expected as with conventional high pH lime and gyp muds. As with lime muds, shale control muds are subject to severe gelations with extended time at high temperature.

Low solids muds. Low solids muds, since they contain no lime, and very small amounts of clay and caustic soda, are better completion or packer muds than conventional high pH lime muds. The primary ingredients of this mud are bentonite, sodium carboxymethylcellulose (CMC); and a very small amount of caustic soda and thinner. Mud weights from 11.0 lb per gal to 19.0 lb per gal are readily obtainable.

Many operators are now making up new completion muds. The low solids, CMC-bentonite mud, because of its stability and ease of mixing, has become quite popular for this purpose.

Low solids, CMC-bentonite muds have universal application as completion fluids. This type mud has also been useful where difficulty was experienced in running perforating and logging tools in deep wells. Spotting a column of CMC-bentonite mud in the bottom of the well has made it possible to run tools. Generally, better performance can be expected from these muds than from conventional high pH lime or gyp muds. Because much of the suspending power of these muds is derived from CMC, a careful study of downhole conditions should precede their use as packer fluids since high temperature degradation of the CMC could result in a serious weight-settling problem in the bottom of the hole.



Diagrams show arrangement of particles in each of the mud systems indicated. From left to right, the first group represents a dispersed mud such as a low pH mud and easily demonstrates the means of mud solids invasion of the formation. The middle group represents mud solids in systems of dispersed flocculation, such as a conventional lime, shale control, or gyp mud. Mud solids invasion would be limited by the aggregated particle size, but filtrate invasion would be difficult to control because of porous structure of the larger particle. Group on the right represents the particle orientation in systems of controlled flocculation such as the surfactant systems. These particles form the best means of controlling particle invasion and filtration.

Surfactant and surfactant-treated muds. These muds have been a recent development in the continuing battle with temperature in deep hot-hole drilling and these muds have been successfully employed as drilling and completion fluids at bottom hole temperatures exceeding 400 F. Basically, surfactant muds are composed of nonionic surfactant mixtures (DMS and DME or HS-400), an electrolyte (gypsum or salt), and a fluid-loss control agent. These muds have had their best application wherever stability and absence of cementation reactions are of greatest importance. Conditioning of these muds is quite simple, requiring only the adjusting of the surfactant concentration, electrolyte concentration, and fluid loss to prescribed limits.

As a completion fluid, surfactant muds can be successfully applied in any well, deep or shallow, normal or high temperature, and regardless of formation pressure. They are extremely stable, even when exposed for long periods of high bottom hole temperatures. If they have been properly conditioned as packer fluids, they can probably be left in the hole for extremely long periods without deterioration. Generally, these muds exhibit excellent resistance to contamination. Salt will have no noticeable effects on the flow properties, nor will cement if the mud is properly pretreated before cement is drilled. The inhibitive nature of the mud furnishes adequate protection to water-sensitive formation, while the extremely low surface tension of the filtrate minimizes any possibility of a water block. Furthermore, the possibility of solids invasion is minimized because these muds are controlled flocculation systems in which the shape and size of the particles are regulated.

Surfactant-treated is a term applied to any conventional water-base mud that has been treated with the primary surfactant (DMS). This treatment has been found to greatly improve the stability and fluid-loss control of conventional muds. Although the stability and performance of these systems as completion muds is improved, it is well to remember that these systems are still subject to the same restrictions as the base mud with somewhat broadened limits.

Oil emulsion muds. These muds are generally considered as being any water-base mud to which oil has been added for the purpose of forming an oil-in-water emulsion and improving the performance of the mud. The treatment and conditioning of these muds is therefore the same as for the base mud where oil is not present and the restrictions that apply to the base mud will apply to the emulsion mud.

Emulsion muds have the same application of the base mud for use during well completions. In general, chemical emulsions formed with soaps, petro-

leum sulfonates, or various surfactant compounds offer certain advantages in completion work as in drilling. These emulsions aid in lowering and controlling the fluid loss and the reduced surface tension of the filtrate minimizes the formation of water blocks. Since the fine oil droplets plug pore spaces in affecting fluid-loss control, it is logical to assume then that there is a reduction or minimizing of the penetration of solids into the formation.

Salt water muds. Salt water muds are not generally employed in routine drilling and completion operations. Their use is limited principally because of their interference with the use of conventional electrical logging devices. The total salinity of these muds varies from about that of sea water to saturation. Maintenance, and conditioning varies with the degree of salinity as does their performance.

In the range of one to five percent salt, these muds are maintained with caustic soda, excess thinner, and a fluid-loss control agent. Above five percent salt, the muds are usually carried to complete saturation because of the difficulty in controlling the flow properties of the mud. This results from the fact that few, if any, of the dispersants are effective as thinners because of the effect of the high sodium ion concentration on the clay particles. Salt muds also present a corrosion problem. This can be overcome by raising the pH to 12 or above or by the maintenance of one-quarter pound per barrel of sodium chromate in the entire mud system.

Salt muds may be used as completion fluids with good results. Above two percent salt these muds will prevent the swelling of hydratable clays. Also, cement has very little contaminating effect on the mud. In fact, lime and cement have on occasions been used to thin salt muds.

Some reservoir engineers believe the best mud for drilling, completion, and work-over operations would be a mud which had the same or slightly higher salinity than formation water and equal chemical environment. Thus, any water that was introduced into the formation would not affect it to any greater degree than the water already present.

Oil base muds. These muds, as opposed to water base muds, are those in which oil rather than water is the continuous phase. True oil base muds are composed of diesel oil, blown asphalt, and stabilizers. They contain very little water. These muds have seen only limited use as drilling fluids, and only somewhat greater use as completion and workover fluids. Their particular advantage lies in their fluid loss. Normally, under API conditions it is very low, and what filtrate does develop is oil.

Oil base muds may be used as completion fluids in any well. At present, however, their use is limited principally to special applications, such as in the case of extremely water sensitive formations. There is some fire hazard connected with its use and it is extremely sensitive to contamination from fresh water. Generally, when oil-base muds are used, it is advisable to cover the mud pits so that fresh water will not come in contact with the mud.

Good results can be expected from oil-base muds. Where water-sensitive formations are involved, few water-base muds can equal their performance. Oil-base muds also make excellent perforating fluids and their stability and resistance to cement contamination ideally suits the requirements of an extensive testing program.

Invert emulsion muds. In the strictest technological sense, invert emulsion muds are oil base muds because oil is the continuous phase. They are water-in-oil emulsions prepared with 40 to 60 percent by volume oil, either crude or refined, and various emulsifying and stabilizing agents. In general, their use and performance is comparable to that of a true oil-base mud.

Invert emulsion muds display excellent resistance to contamination from cement and water, either fresh or salt. Should a large quantity of water accidentally be introduced into the system, it is easily overcome by the appropriate additions of oil and emulsifier. Conditioning these muds involves adjusting the oil-water-ratio and physical properties with oil or water and emulsifier.

Field use indicates that invert emulsions have the same application as oil base mud. The fact that their cost of preparation is about half that of the same weight oil base mud has made their use quite attractive to many operators. Bottom hole temperature is the only factor which makes their use questionable. At the present time, their use is limited to bottom hole temperatures which do not exceed 270 F.

Chemical Solution Packer Fluids

During recent years, chemical solution packer fluids have started replacing packer muds. Chemical solutions possess many of the properties which are desirable for completion and packer fluids. They can be prepared to acceptable densities (8.5 to 12.5 lb per gal), are non-corrosive, and free of solids. In addition, they inhibit swelling of bentonite clays in the producing formation. A properly mixed solution contains no undissolved solids and thus can not cause plugging of the perforation channels. Furthermore no precipitation of solids onto a packer after long periods of standing, nor high temperature gelation or solidification can occur.

Four aqueous salt solutions are commonly used, at present. They are saturated solutions in water of sodium chloride; soda ash and sodium chloride; calcium chloride; and sodium nitrate. Saturated sodium chloride brines have for many years been used extensively on completion and workover operations. Brines prepared with other salts should find greater acceptance in the future. At present, these salt solutions are being employed primarily as packer fluids.

These solutions have application in any well. The only factors which presently limit their use are the inability to economically obtain densities above 12.5 lb per gal, loss of the fluid to extremely porous and permeable formations, and minimum well bore temperature. In cases where there is some loss of fluid to the formation, any of the above-mentioned brines may be treated with various surface active agents to reduce possible reservoir damage.

Conclusions

It is difficult to justify the use of one particular mud over another on the basis of cost alone. Frequently, the protection offered to the formation and the expediting of completion operations cannot be accurately determined in dollars and cents. The importance of selecting the proper completion mud or proper conditioning of the existing drilling mud cannot be over-emphasized. New discoveries will, for the most part, be less prolific and will probably be from dirty reservoirs. This is because of the need for completing in several broken zones in silty or shaley formations. Many of the wells now being completed, or to be completed in the future are in formations which as early as 10 years ago could not or would not have been considered for completion.

When reservoir conditions permit, the drilling mud usually becomes the most economical completion mud. If the drilling mud is used, it should be in the best condition possible before completion operations are begun. Likewise, when special muds are to replace the drilling fluid they also should be in the best possible condition before completion operations are started. Regardless of which route is taken, the selection of the completion mud should be made on the basis of three considerations:

1. Provide adequate protection to the producing formation.
2. Remain stable throughout the sequence of operations to be performed.
3. Be economical. ★ ★ ★

Continuous Flow Gas Lift Design

Comparison of detailed and standard field procedure shows advantages of each method in determining correct point of gas injection

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THE PROPER DESIGN of a continuous flow gas lift installation depends on accurate well data. In many instances, gas lift installations are made with a complete lack of vital well information. For this reason a flowing pressure survey is beneficial after the first installation in order to allow a correct respacing of the valves. In many instances, however, good gas lift installations have resulted even with a minimum amount of well information.

It is generally conceded that the most important factor in continuous flow design is the determination of the correct point of gas injection. Past well performance has shown that the lower the gas injection point, the lower the injection gas-oil ratio. The principal governing factors in design are (a) the available injection gas pressure and volume, (b) the wellhead tubing back pressure, (c) the flowing bottom hole pressure, (d) the well fluids, which include oil, gas and water, and (e) the size and depth of the eductor tube.

Two methods are presented whereby the point of gas injection can be determined. Both methods will make use of the maximum surface injection gas pressure.

The first method, which will be referred to as the "Simplified Procedure," can be used to determine the point of gas injection quickly by the use of a graph.

The second method, referred to as the "Detailed Procedure," was presented originally by Fred H. Poettman and Paul G. Carpenter of the Phillips Petroleum Company and later simplified by the use of charts from C. V. Kirkpatrick. The detailed procedure is explained and a modified version of this method by the use of "Standing's Composite Volume Factor Chart" is presented. Several curves are included showing a comparison of the two methods.

Reference should be made to Fig. 1 which shows continuous flow gas lift nomenclature in common usage today.

Simplified Procedure

In this procedure, maximum benefit is derived from the available injection pressure. This means that the deepest point of injection will be obtained, depending upon the injection gas pressure. This method involves a minimum of time and therefore is quite popular.

The following step-by-step procedure will serve as a guide for designing an installation on this basis. Plot all information on a sheet of rectangular coordinate paper.

1. Plot depth on the ordinate (vertical) with zero depth at top and maximum depth at bottom.
2. Plot pressure on the abscissa (horizontal) with pressure increasing from 0 at the origin to a maximum.
3. Plot the static bottom hole pressure (BHP) at the correct depth.
4. Plot the expected flowing tubing pressure at zero depth (top of page).
5. From the productivity index (PI) calculate the pressure drawdown necessary to obtain the desired amount of production.
6. Subtract the drawdown from the static bottom hole pressure. This is the expected flowing bottom hole pressure and should also be plotted at the bottom or producing interval depth.
7. From the percent water and API gravity of the oil, calculate or obtain a static gradient of the mixture.
8. Plot a static gradient line up the hole from both the static BHP point and the flowing BHP point. Extend the static BHP line to the depth line. This will be the static fluid level for zero back pressure. Extend the flowing BHP line to the depth line. This will be the effective lift with zero back pressure.
9. Extend the tubing pressure line down the hole, accounting only for the weight of the gas column in the tubing. Its intersection with the flowing bottom hole

CONTINUOUS FLOW NOMENCLATURE

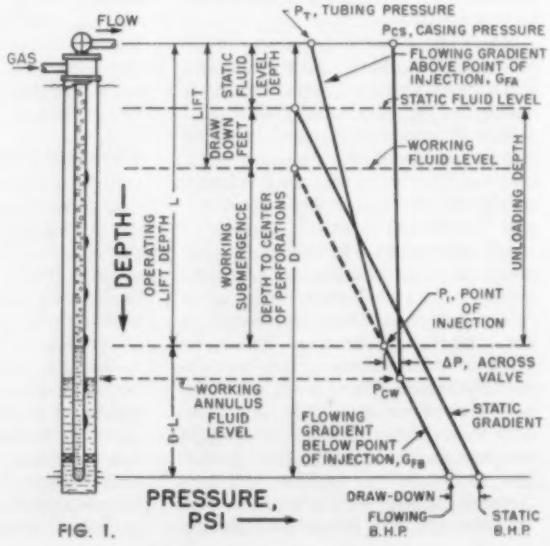

FIG. 1.

Presented at the Sixth Annual "West Texas Oil Lifting Short Course" at Texas Technological College, May, 1959.

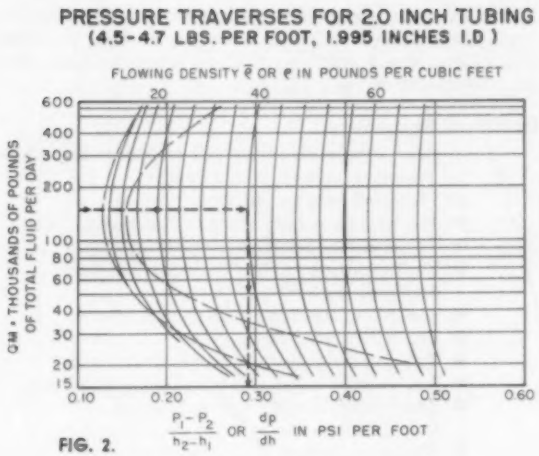

FIG. 2.

pressure line will be the actual "effective lift" for any particular well.

10. Plot the surface injection gas pressure at zero depth.
11. Check the gas column weight.
12. Starting from the surface injection gas pressure, plot the casing pressure down the hole, taking into account the weight of the gas column.
13. Extend the casing pressure line until it intersects the flowing bottom hole pressure line. This point is commonly called the "working annulus fluid level."
14. Subtract 100 psi from the pressure in the casing at this point. Return up the hole a distance equivalent to 100 psi on the flowing bottom hole pressure line and note this point. This will be the point of gas injection.
15. Connect, by a straight line, this point of gas injection to the surface flowing tubing pressure. This line represents an average maximum flowing gradient between the tubing pressure and the point of gas injection. In other words, if gas is being injected at this point, a minimum gas-oil ratio for the injection pressure available should be realized.

The following additional steps are offered to help make proper valve selections:

16. Plot the geothermal gradient for the well on the same graph paper. This should be a gradient for the well while flowing. This is usually an unknown factor and may vary considerably from the earth's normal geothermal gradient. For example, a well with 250 F bottom hole temperature and making 3000 bbl per day, may have more than 200 F surface flowing temperature. Therefore, the best available information as to surface flowing temperatures must be utilized. This surface temperature is then plotted at zero depth. The bottom hole temperature is then plotted at its correct depth. A straight line between these two points will establish the flowing geothermal gradient for the tubing string. (Cooling caused by the expanding gas at the injection point should be considered if it is appreciable.)
17. Establish the temperature at the operating valve. (Point established as point of gas injection.)
18. From the surface injection gas pressure, deduct 50 to 100 psi, which will be the surface opening pressure of the operating valve.
19. Select a gas-lift valve to operate at the surface opening pressure as set out in Step 18. In other words, select a valve to open at the desired pressure, which will account for temperature, gas column weight, and back pressure effect. (All valves do not necessarily incorporate all these variables.)
20. Space the valves, starting with casing pressure minus 50 psi.
21. Take the bottom valve setting at surface setting temperature and select all valve settings. From the bottom up, each valve should be increased from 15 to 25 psi in opening pressures at setting temperatures.
22. From correct temperatures and gas column weights, check the surface opening pressure of each valve.
23. Make any necessary adjustments in valve settings to make certain that all valves can be opened and that no interference of valves is present.

It should be understood that average gradients, both above and below the point of gas injection, have been used in this particular procedure. For wells making large percentages of water, the flowing gradient below the point of gas injection will be approximately the same as the static gradient. The flowing gradient above the point of gas injection will vary from a high value at the point of injection to a lower value at the surface. However, a straight line from the point of gas injection to the tubing pressure establishes an average gradient between these two points.

The point of gas injection may be solved analytically as follows:

P_i = Pressure in tubing at point of injection
P_t = Tubing pressure (surface)
P_{cs} = Surface Casing Pressure
G_{Fa} = Flowing Gradient above point of gas injection
G_{Fb} = Flowing Gradient below point of gas injection
FBHP = Flowing botton hole pressure
SBHP = Static bottom hole pressure
D = Total Depth
L = Depth to point of gas injection
P_{cw} = Pressure in casing at working fluid level

Starting at the top of the hole and summing up pressures to the bottom.

$$P_t + G_{Fa}(L) + G_{Fb}(D - L) = \text{FBHP (flowing pressure)} \quad . \quad . \quad . \quad (1)$$

$$\text{Now: } G_{Fa} = \frac{[(P_{cw} - 100) - P_t]}{L} \quad . \quad . \quad . \quad (2)$$

substituting (2) in (1)

$$P_t + \frac{[(P_{cw} - 100) - P_t](L)}{L} + G_{Fb}(D - L) = \text{FBHP}$$

$$(P_t) + P_{cw} - 100 - (P_t) + G_{Fb}(D) - G_{Fb}(L) = \text{FBHP}$$

$$L = \frac{(P_{cw} - 100) + (G_{Fb})(D) - (\text{FBHP})}{G_{Fb}}$$

Procedure:

(a) Make one calculation using $P_{cw} = P_{cs}$ and solve for a depth.
(b) From this depth obtain a weight of the gas column.
(c) Add P_{cs} + wt of gas column = P_{cw}
(d) Using P_{cw} from (3), solve for another depth.
(e) Repeat the procedure until the assumed value of ΔP corresponds with the value of ΔP for the solved depth.

Sample Calculation:

Given:
D – 8000 ft
Flowing tubing pressure – 100 psi
S.G. = .65
FBHP for desired production – 2500 psi
Flowing gradient below the point of gas injection = .45 psi/ft

Surface injection pressure – 950 psi

1st Trial

$$L = \frac{(P_{cw} - 100) + G_{Fb} \times D - FBHP}{G_{Fb}}$$

(Assume $P_{cw} = P_{cs}$)

$$L = \frac{950 - 100 + (.45)\ (8000) - 2500}{.45}$$

$$L = \frac{1950}{.45} = 4340 \text{ ft}$$

From appropriate charts or from calculations the weight of this gas column is found to be 100 psi.

2nd Trial: Assume $P_{cw} = 950 + 100 = 1050$ psi

$$L = \frac{1050 - 100 + (.45)\ (8000) - 2500}{.45}$$

$$L = \frac{2050}{.45} = 4560 \text{ ft} \quad \text{Gas Column wt} = 105 \text{ psi}$$

3rd Trial: Assume $P_{cw} = 950 + 105 = 1055$ psi

$$L = \frac{1055 - 100 + (.45)\ (8000) - 2500}{.45}$$

$$L = \frac{2055}{.45} = 4565 \text{ ft}$$

The gas column weight for 4565 ft is approximately 105 psi. Therefore, 4565 ft is the correct point of gas injection. It is evident that a graphical solution is simpler, and offers less chance for error.

Detailed Procedure

1. In order to properly utilize this procedure the following information must be obtained:
   - The producing gas-oil ratio.
   - The specific gravity (SG) of the injection gas.
   - The specific gravity of the solution gas.
   - The formation volume factors at different pressures. (FVF)
   - The gas in solution at different pressures.
   - The API gravity of the oil.
   - The specific gravity of the produced water.
   - The amount of oil and water being produced.
   - The flowing surface tubing pressure. (accurate estimation)
   - The static bottom-hole pressure.
   - The productivity index (P.I.) of the well.
   - The depth to the center of the perforated interval.
   - Bottom-hole temperature.
   - Estimated surface temperature and temperature gradient.
   - Tubing size.
2. Using a sheet of rectangular coordinate paper, plot the flowing bottom-hole pressure and the flowing

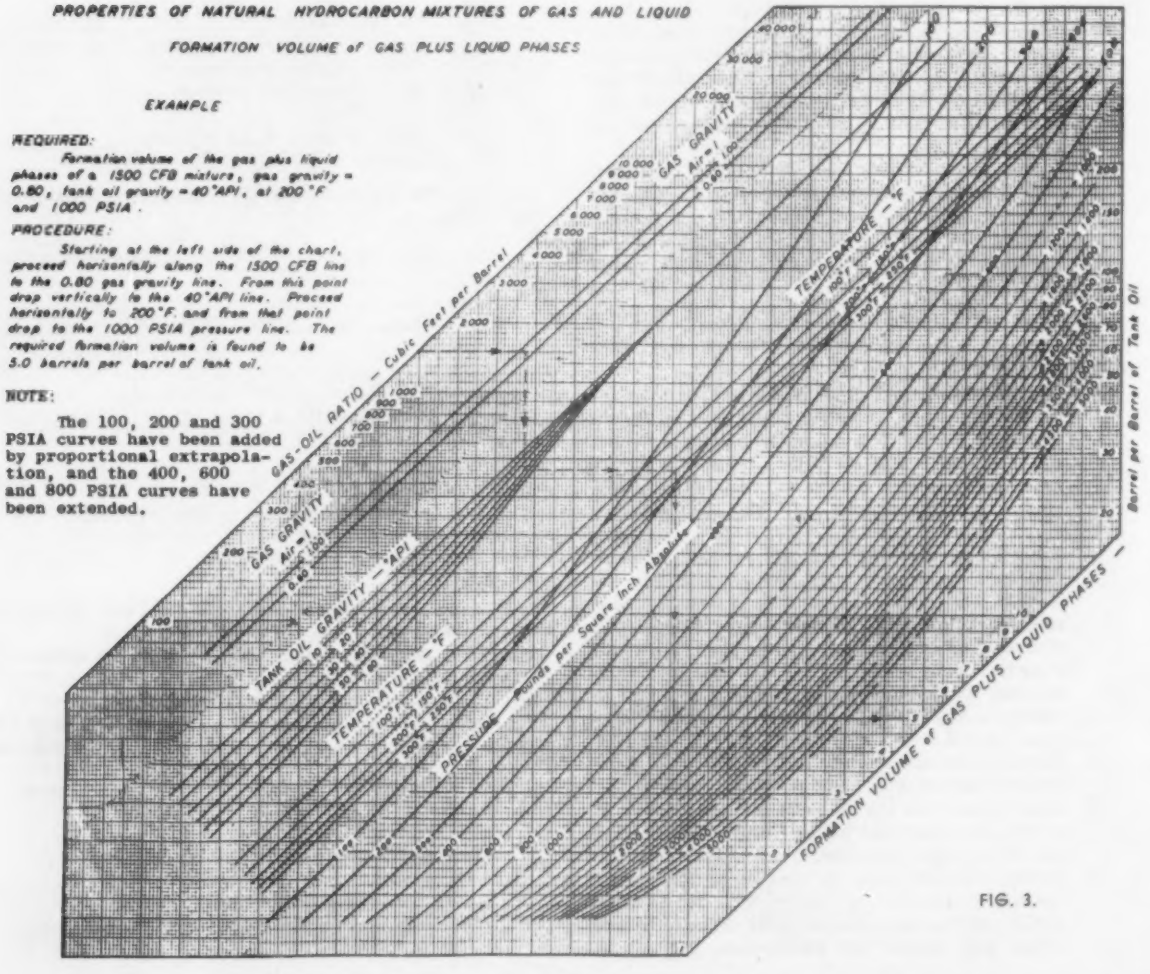
PROPERTIES OF NATURAL HYDROCARBON MIXTURES OF GAS AND LIQUID
FORMATION VOLUME of GAS PLUS LIQUID PHASES
EXAMPLE
REQUIRED:
Formation volume of the gas plus liquid phases of a 1500 CFB mixture, gas gravity = 0.80, tank oil gravity = 40°API, at 200°F and 1000 PSIA.
PROCEDURE:
Starting at the left side of the chart, proceed horizontally along the 1500 CFB line to the 0.80 gas gravity line. From this point drop vertically to the 40°API line. Proceed horizontally to 200°F. and from that point drop to the 1000 PSIA pressure line. The required formation volume is found to be 5.0 barrels per barrel of tank oil.
NOTE:
The 100, 200 and 300 PSIA curves have been added by proportional extrapolation, and the 400, 600 and 800 PSIA curves have been extended.
GAS-OIL RATIO — Cubic Feet per Barrel
GAS GRAVITY Air=1
TANK OIL GRAVITY — °API
TEMPERATURE — °F
PRESSURE — Pounds per Square Inch Absolute
FORMATION VOLUME of GAS PLUS LIQUID PHASES — Barrel per Barrel of Tank Oil

FIG. 3.

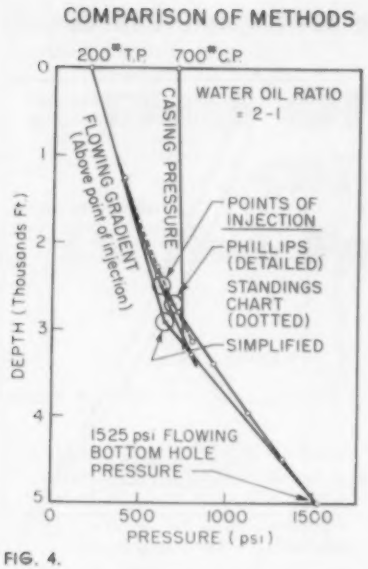

FIG. 4.

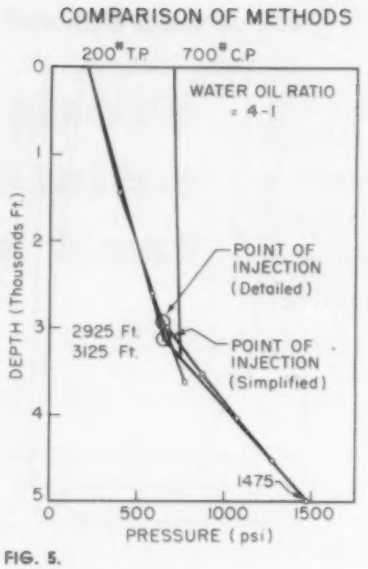

FIG. 5.

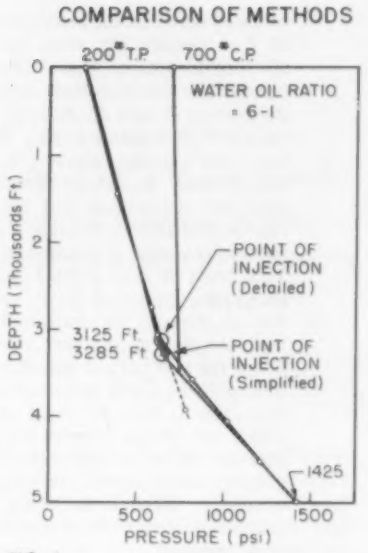

FIG. 6.

tubing pressure. Plot pressure vs depth as set out in the simplified procedure.

3. Determine the mass rate of flow (M_b) below the point of gas injection in pounds per barrel of stock tank oil (S.T.O.).

M_b = wt of oil + wt of gas + wt of water

M_b = (350) (S.G. oil) + (.0764) (S.G. gas) × (Producing G/O + 350) × (S.G. water) (water oil ratio)

The total pounds of fluid ($Q M_b$) produced per day is:

$$QM_b = (M_b)\ (\text{daily S.T.O. production})$$

Note: This is to be used on the gradient chart (Fig. 2) to establish a fixed ordinate.

4. Starting with the flowing bottom hole pressure, assume various decreasing pressure points. Select pressure increments close enough to obtain a good curve (try 200 psi increments for a start).

5. Calculate the flowing density ($\bar{e}$) at each one of these pressure points, including the flowing bottom hole pressure point. Density is defined as weight per unit volume.

First calculate the volume in cubic feet occupied at any pressure point by everything associated with one stock tank barrel of oil.

Total volume = Vol of Oil + Vol Gas + Vol Water

$$= (5.61)\ (FVF) + (\text{Free Gas})\left(\frac{(P_b)\ (T)\ (Z)}{(P)\ (T_b)\ (1)}\right) + (5.61)\ (\text{water oil ratio})$$

Note – for volume of gas:

First, check for gas in solution with the oil at the pressure point you are working with. Subtract this from the producing gas-oil ratio. This will be the free gas at this pressure point.

$$\text{Vol gas} = (\text{Free Gas})\ \frac{(\text{Base Pressure})}{(\text{Pressure})}\ \frac{(\text{Temp})}{(\text{Base Temp})}\ \frac{(Z)}{(1)}$$

Where:

Free Gas = (Producing Ratio) minus (gas in solution at P)

P_b = 14.70 psia

T_b = 60 F = 460 + 60 = 520 F absolute

P = Pressure (pressure at assumed pressure point)

T = temperature at assumed pressure point

Z = compressibility factor (to be determined from critical temperature and pressure and actual temperature and pressure).

Density is determined thus:

$$P = \frac{M}{V_m}$$

where: P = density in lb per cu ft.

M = Mass flow rate, lb per STB

V_m = Volume of oil, water, and gas produced per STB, cu ft.

6. The flowing gradient is then obtained from a chart similar to Fig. 1 at the pressure point assumed. This chart includes friction.

Reference to Fig. 2 shows that values are not available for lower density ranges, and that increased gradients are noted for densities less than 10 lb per cu ft. Some controversy exists as to the reliability of this method in these ranges. It is reported that an actual increase in flowing gradient occurs in this so-called turnover range. However, until further reliable information is available, these lower values can be handled by extrapolating a curve as plotted on an arbitrary depth scale, and relating this curve to the actual problem.

7. Once the flowing gradient has been determined in the tubing for the flowing bottom hole pressure, the same procedure is followed in determining a gradient for the next pressure point (FBHP-200).

8. From the two flowing gradients determine an average (avg.) between them.

$$\frac{G_{F_1} + G_{F_2}}{2} = G_{F_{avg}}$$

where G_{F_1} = flowing gradient at point (1)

G_{F_2} = flowing gradient at point (2)

9. From the difference in pressure between these points determine the distance between them.

$$\frac{P_1 - P_2}{G_{F_{avg}}} = \frac{\Delta P}{G_{F_{avg}}} = \text{distance in ft}$$

10. This distance is then plotted up from bottom.

11. The same preceding series of steps is repeated for the next reduced pressure point up the hole. It should

be noted here that the mass rate of flow remains the same for all pressure points below the point of gas injection. However, the flowing density changes because of the expanding gas.

12. Using the average flowing gradient between the point of pressure just determined and the one immediately preceding it, another distance is calculated. This point is then plotted on the graph.
13. This operation is continued until the flowing gradient line below the point of gas injection intersects the depth line on the plot. This is then the point at which the flowing bottom hole pressure could be expected to support the fluid in a flowing condition. This is sometimes called the effective lift for zero back pressure.
14. The casing pressure is plotted in the same manner, but including the weight of the gas column, until the line intersects the plotted fluid gradient line. The point of gas injection is obtained by moving up the hole an equivalent footage of 100 psi.
15. Calculations must now be started from the tubing pressure and come down the hole by 200 psi increments. To start this procedure, first of all assume some injection GOR. From the effective lift determined previously, a value of 200-300 cu ft per bbl per 1000 of effective lift is selected. The steps are the same as outlined above except that a new mass rate of flow is determined which now includes the weight of the injection gas. In figuring volume (Vm), the new volume will also include the volume of the injected gas.
16. Again, working with 200 psi or smaller increments, this curve is plotted until it intersects with the flowing gradient line below the point of gas injection.
17. This point of intersection is then the point of gas injection for this particular injection gas oil ratio.
18. Various injection GOR should be assumed until one of the curves coincides with the previously established point of gas injection.
19. If a compressor is being selected for the job a further plot of injection pressure vs injection gas oil ratio, and injection pressure vs HP should be made to determine the most efficient lift.

The above procedure seems rather tedious and complicated, but can be simplified by the use of "Standing's Composite Volume Factor Chart" (Fig. 3). It can be seen that the volume occupied by both the oil and gas can be immediately selected from this chart. Therefore, it is only necessary to add the ratio of water per stock tank barrel of oil to a value from this chart to yield the composite volume factor of oil, gas and water (Jogw). Then the density in

$$\text{lb/cu ft} = \frac{M_b}{(5.61)\ (\text{Jogw})} \cdot \text{The procedure}$$

in utilizing the Standing chart is exactly the same as in the detailed procedure except the volume calculations are simplified.

The detailed method as modified by the use of the Standing chart can be used to locate the exact point of injection quickly if combined with the Simplified Procedure. This is done by substituting the gradient below the point of injection (which does not take into account the formation gas) with the gradient as plotted from the use of Standing chart.

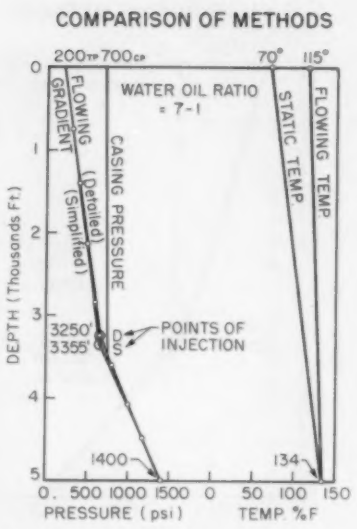

FIG. 7.

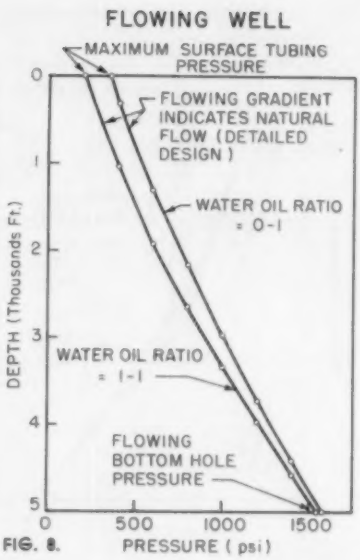
FLOWING WELL
MAXIMUM SURFACE TUBING PRESSURE
FLOWING GRADIENT INDICATES NATURAL FLOW (DETAILED DESIGN)
WATER OIL RATIO = 0-1
WATER OIL RATIO = 1-1
FLOWING BOTTOM HOLE PRESSURE
DEPTH (Thousands Ft.)
0 500 1000 1500
PRESSURE (psi)

FIG. 8.

If it is not necessary to determine an exact injection GOR, the point of gas injection is determined by returning up the hole a distance equivalent to 100 psi from the point at which the casing pressure line intersects the gradient line (Step 14, "Simplified Procedure"). The difference in pressure should be no less than 25 psi and no more than 100 psi. This differential pressure (25 – 100 psi) is required in order to allow the well to unload to this point and permit sufficient gas volume entry. Once this depth has been reached, the differential can be decreased if the injection GOR is too high.

With the advent of gas lift valves that regulate the same gas volume into the tubing as is injected into the casing, the problem of having to calculate injection GOR's to establish a choke size is eliminated. It is only necessary to regulate different injection volumes into the casing annulus at the surface, until the most efficient producing GOR is established.

A comparison of these two methods has been made utilizing the following problem:

(1) Depth to the center of the perforated interval 5000 ft.
(2) Static bottom-hole pressure — 1600 psi.
(3) Water specific gravity 1.07.
(4) Water-oil ratios—1:1—1:2—1:4—1:6—1:7.
(5) Desired to produce 100 bbl of oil per day.
(6) Tubing size — 2⅜-in. OD.
(7) Producing GOR — 500 – 1.
(8) Specific gravity of the produced gas = .60.
(9) Specific gravity of the injection gas = .60.
(10) Specific gravity of the oil = .802 (45 API).
(11) Surface tubing pressure = 200 psi.
(12) Surface injection gas pressure = 700 psi.
(13) Bottom hole temperature = 134 F.
(14) Surface flowing temperature = 114 F.
(15) Mean surface temperature = 70 F.
(16) Productivity index (P.I.) = 4.0.

The results of solving this problem by both methods for various water oil ratios are shown in Fig. 4, 5, 6, 7, and 8.

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Sea of Japan site of...

First Offshore Oil Strike in the Far East

Flowing oil discovery on the continental shelf off Japan's Honshu Island climaxes a ten-year underwater exploration program including gravitimeter and seismograph surveys

Joseph A. Kornfeld, *Manager, Kornfeld International, Tulsa, Oklahoma*

THE WORLD'S NEWEST offshore oil province came into production during November, 1959, with the official announcement of the completion of a flowing oil well drilled from a platform situated 1.4 miles off Akita City on the northwestern shores of Honshu Island, the mainland of Japan.

Establishing the first commercial crude oil production obtained from an offshore well location drilled from a mobile platform in the entire Far East region, the strike is due to bring impetus to exploration in many Tertiary basins situated through a vast region of the Asian continent, long dependent almost entirely upon imports to meet domestic requirements.

Although the Japanese domestic oil industry is more than 60 years old, current crude oil production rates, averaging 7021 bbl per day, amounts to only 2.53 percent of the 1958 refinery runs of 277,400 bbl per day. Current growth of Japanese domestic crude demand, rated at six percent, does not reflect the potential growth, due to Japanese government legislative action designed to lower imports to conserve currency.

The emphasis of the Japanese government in backing a crash exploratory program is designed to treble current oil production rates by 1961.

The discovery well, situated about 340 miles across the mainland and north of the capital city of Tokyo, was reported producing an estimated 2000 bbl of oil per day accompanied by 375,000 cu ft of gas per day on initial flow tests.

The well, drilled and operated by Oil Resources Development Corporation (ORDC), was drilled in 50 ft of water on the broad continental shelf which extends for 640 miles along the northwest side of Honshu Island. Drilled to a total depth of 4766 ft in Tertiary rocks, it was plugged back, production casing was set, and the well was completed from a pay depth reported at 1850 ft.

Ten-Year Exploration Period

The discovery crowns a decade of underwater exploration conducted offshore from Akita Prefecture commencing back in 1949. Gas seeps were examined and plotted on maps. Submarine coring operations were conducted on the sea floor over local structures. This work was followed by skin-divers, experienced in conducting underwater geological surveys, sampling sub-crops on the sea floor of the continental shelf.

This preliminary geological work was followed by the geophysical phase which first employed gravitimeter surveys. Marine seismic surveys were initiated during 1956 in the Akita basin, then expanded southwest to geological anomalies lying adjacent to Niigata and Yamagata Prefectures.

FIG. 1. **First offshore oil strike** from a mobile drilling platform in the Far East is shown by arrow near Akita City in the Akita basin lying on the northwest side of Honshu Island, the mainland of Japan. Stippled area outlines the offshore oil province lying adjacent to existing oil fields out to depths of 300 meters from shore.

Four seismic anomalies were outlined in this offshore oil province for an overall distance of approximately 37 miles extending along the west and northwest side of Honshu Island. Geophysical Services, Inc., an American firm, conducted detailed reflection seismograph surveys offshore Akita Prefecture during 1957. The discovery well was drilled on the principal anomaly outlined as a result of this survey.

Exploratory Drilling Background

Prior to the pioneer offshore platform discovery well in Japan, two exploratory wells were drilled directionally under the water from a shore position.

Akita basin. The first directionally-drilled well in the Akita basin was situated at Tsuchizakiminato about three miles northwest of Akita City. It was completed as a dry hole.

Sakata basin. A second directionally-drilled well was drilled at the village of Fukura on the shores of the Sea of Japan in extreme northern Yamagata Prefecture; it is 45 miles south and slightly west of Akita City but in a separate geologic basin. The Fukura discovery well was completed during 1958 from a producing depth of only 2740 ft. Initial production was 260 bbl of oil per day produced through a 3/16-in. choke.

Michikawa-oki. The first well drilled in the Sea of Japan with the triangular offshore drilling platform was located at Michikawa-oki S.K. No. 1, situated about one mile from shore. The platform was purchased by JAPEX during 1958 from R. G. LeTourneau, Inc., of Longview, Texas. Drilling operations on this initial venture were conducted for ORDC by Zapata Offshore Drilling Company of Houston, Texas, commencing on October 7, 1958. After a depth of 3172 ft was reached, the test was plugged and abandoned on November 22, 1958, after failing to find commercial oil production.

After completion of this well, the platform was towed to nearby Akita harbor as a precautionary measure because of high winds which occur during winter months. Meanwhile, Japanese engineers were sent to the United States to study drilling techniques employed in drilling offshore wells in the Gulf of Mexico.

Akita discovery well. At the northern latitudes of Honshu Island, the drilling season is limited to the period extending from April to November of each year. Consequently, on April 2, 1959, at the commencement of the drilling season, the rig was towed from its harbor moorings to the drill site selected 1.4 miles offshore from Akita City by drilling personnel selected by JAPEX.

Japanese technical personnel, trained in American offshore drilling methods, conducted the entire operation. The total crew, numbering 45, lived on the platform which the Japanese call "Kakuryu," or White Dragon.

Future drill sites. The series of anticlines confirmed by reflection seismograph lie in a belt situated about 2.5 miles offshore and paralleling the coast for a distance of 37 miles in extremities. These structures lie in water ranging from 30 to 90 ft in depth, and the anomaly farthest from shore is 30 miles.

Following completion of the discovery well, the platform has been moved to the next anomaly located 10 miles north of the discovery well at Fanakoshi where drilling is now underway.

Drilling Equipment

Early in 1958, a special committee of Japanese engineers and financial leaders visited the United States for an extensive study of all available platform types. As a result of this study, a contract was made by the government-formed Japan Petroleum Exploration Company, Ltd., of Tokyo which paid the firm of R. G. LeTourneau, Inc., $1,500,000 in U.S. money to supply "component parts and technical guidance" needed to construct Japan's first offshore oil drilling platform.

(The Japanese government owns 56.5 percent interest in the JAPEX firm while principal non-governmental stockholders reportedly are 14 leading oil refineries including Teikoku Oil Company, Ltd., Idamitsu Kosan Company, Ltd., Kos Oil Company, Ltd., and others.)

The hull and legwork of the 4000-ton triangular-legged platform were built by a Nipponese shipyard at Akita, only a few thousand ft from the locale of Akita 1, requiring only a short tow to bring the platform into its drilling position.

Japan Hydrocarbon Production

Crude oil production in Japan during 1958 totaled 2,562,665 bbl which included 14,990 bbl of natural gasoline, or an average of 7021 bbl daily. This compares with a total production during 1957 of 2,269,935 bbl, or an average of 6219 bbl daily.

Natural gas production in Japan during 1958 reached 12,986,281 Mcf, a gain of 51 percent over the 1957 annual production figure of 8,602,481 Mcf.

A three-year trend in crude oil and natural gas production for Japanese indigenous production is shown in Table 1.

Hydrocarbon Occurrences

The oil fields of Japan lie in the northern part of Honshu Island (the mainland) and the island of Hokkaido. The locations of the oil fields are shown in Fig. 1.

Nearly all of the producing fields lie in the Tertiary system with the principal production being found in beds of Miocene age. About 98 percent of the crude oil production of Japan has been obtained within Akita and Echigo Prefecture.

Geologic History

The present oil fields of Japan originated from a series of once interconnected basins which formed a large elongated Tertiary geosyncline. In late Miocene time, crustal movements separated the geosyncline into six regional basins:

Hokkaido Island: Central Hokkaido basin.

Honshu Island: Aomori basin, Akita basin, Yamagata basin, Niigata basin, and Shizuoka basin.

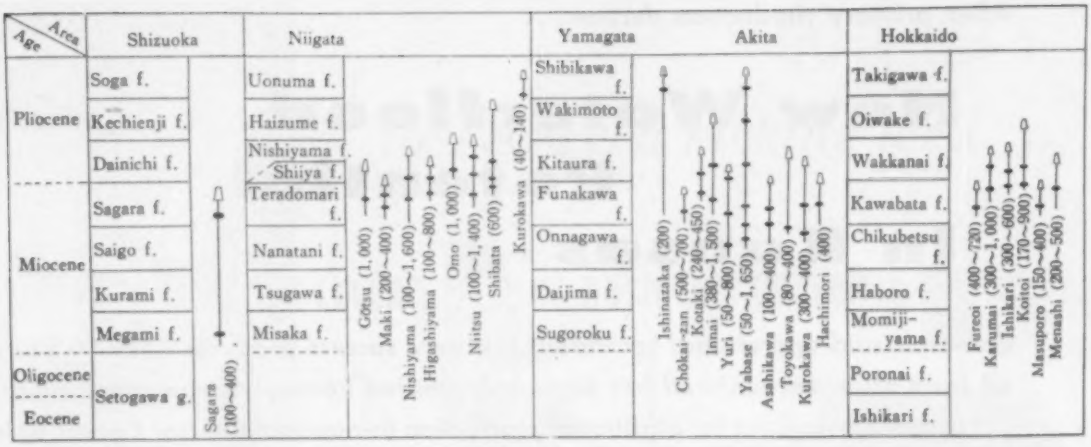
In the central portion of each of these isolated basins, several thousands of Pliocene and Pleistocene beds were land down. However, by early Pleisto-

TABLE 1. Recent Oil and Gas Production in Japan.

Year	Crude Oil Production		Natural Gas Production	
	Daily —bbl	Annual —bbl	Daily —Mcf	Annual —Mcf
1956	5978	2,181,970	16,726	6,105,000
1957	6219	2,269,935	23,568	8,602,481
1958	7021	2,562,665	35,579	12,986,281

TABLE 2. Cumulative Oil Recovery from Leading Japanese Oil Fields to July 1, 1958.

Field and Date of Discovery	Depth Range —ft	Average Gravity — deg API	Cumulative Oil Recovery Bbl	Percent
Yabase, 1933	200-5640	25	35,763,270	39.50
Nishiyama, 1888	500-6300	37	18,698,000	20.65
Niitsu, 1896	160-4750	19	18,080,130	19.97
Innai, 1923	660-3530	23	7,749,360	8.56
Nigashiyama, 1893	460-2180	28	7,545,110	8.33
		Sub-total (five leading fields)	87,835,870	97.03
		Remainder	2,693,090	2.97
		Total Japan to July 1, 1958	90,528,960	100.00



Figure····· Average depth

f.····· Formation

g.·····Group

FIG. 2. **Geologic correlation table** of oil-producing formations for various fields in Japan includes the Akita field, site of Japan's new offshore oil well. (After K. Kaneko.)

cene, these beds were folded and faulted by a series of sharp orogenic movements. These folded lands, with the sole exception of Aomoro basin, formed a series of oil-bearing belts which exhibit a general strike of N-NE to S-SW, particularly in the marginal region lying between the alluvial plains and the hilly uplands.

Geologic Structures

During the 77-year period from 1874 (the year production records commenced) to 1951, 57 producing oil fields were discovered in Japan. Of this group, 53 fields were developed on anticlines. Fault-type structures accounted for two fields: Narahashi and Ishinazaka. Stratigraphic traps formed two other fields: Edhigo-Kurokawa and Shibata.

On the island of Honshu, the structural pattern is that of small, elongated anticlinal folds which strike roughly parallel to the mountainous backbone of the island and the general trend of the coast of the Sea of Japan.

On the island of Hokkaido, the anticlinal structures do not exhibit the intensity of folding as compared to those in Honshu, but some of them indicate gentle domes of considerable magnitude in the Central Hokkaido basin.

Petroleum Source Beds

On the island of Honshu, the petroleum source rocks are considered to be divided into two origins of Tertiary age:

Black shale beds: Funakawa formation in Akita Province; Teradomari formation in Niigata Province.

Siliceous shale beds: Onnagawa formation in Akita Province; Nanatani formation in Niigata Province.

On the island of Hokkaido, the oil source beds are considered to be the mudstones or the shale beds of Miocene and Pliocene age.

Petroleum originating from pre-Tertiary sediments is confined to the Cretaceous formation on the island of Hokkaido and the Jurassic rocks in the Kochi Prefecture. The only oil-bearing rock of Jurassic age in Japan is the Torinosu limestone which outcrops in a village of Kochi Prefecture.

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SUMMARY: JAPANESE OIL LEGISLATION

Basic law entitled "Development of Petroleum and Inflammable Natural Gas" was approved on January 31, 1951, by the Japanese government.

- **Basic royalty payments** — Royalty is paid on a sliding scale on the basis of market value up to a maximum of two percent.
- **Exploration contract periods** — The term of the initial exploration period is two years. Extensions may be made, subject to government approval, up to a maximum of three consecutive 2-year exploration periods.

Revised law entitled "Petroleum and Inflammable Natural Gas Resources Development Law" was approved in June, 1952. The law is administrated by the Petroleum Resources Council, a special technical committee appointed by the Japanese government.

- **Unit operation** — The law provides for unitization of leaseholds to achieve optimum well spacing, proper control of gas-oil ratios, water-oil ratios, and reservoir energy.
- **Government subsidies** — Government subsidies are arranged to encourage investment of additional capital in pressure maintenance or secondary recovery operations to permit maximum recovery of hydrocarbons.

SPECIAL NATIONAL TAXES

- **Dividend transfers** — An American corporation is allowed to transfer dividends which are protected with a guarantee of exchange privileges. However, at the end of a 2-year deferment period, remittances can be exported up to a maximum of 20 percent per year of the original capital investment in Japanese oil operations.
- **Local enterprise tax** — A local enterprise tax of 12 percent of gross revenue is levied and payable annually by companies.
- **National corporation tax** — Corporations pay a national corporation tax amounting to 35 percent of annual gross revenue totaling below $1385 (500,000 yen). However, the tax rises to 40 percent of annual gross revenue totaling above $1385 per year.
- **Undistributed profits tax** — On undistributed corporation profits, family corporations pay 5 percent of gross earnings over $1385 per year. (A family corporation is defined as a Japanese corporation in which more than 30 percent of the shares are owned by another corporation, such as a Japanese subsidiary of an American corporation.)

After primary production decline . . .

New Waterflood Potential In Kansas

Economic and operational secondary recovery success produces 142,000 bbl of oil from often-encountered but previously untried Pennsylvanian conglomerate . . . opens possibilities for additional production throughout Central Kansas uplift

Edgar L. Leissner
Champlin Oil & Refining Company
Fort Worth, Texas

A WATERFLOOD PROJECT instigated by Champlin Oil & Refining Company in February, 1956 may eventually prove to be a boon to secondary recovery in the Central Kansas uplift. This flood was on the wholly-owned Brungardt unit, Ellis and Rooks counties, and the objective horizon was the often-encountered Pennsylvanian conglomerate of Central Kansas.

It is felt that the importance of this project lies in application of the waterflood technique to an untried conglomerate horizon. Of the over 200 active waterfloods reported by the State Geological Survey of Kansas in its 1957 survey, the Brungardt unit is the only flood cited as in the Pennsylvanian conglomerate. Though it is not reasonable to assume that all conglomerate reservoirs will respond to waterflooding, nevertheless, if a small portion of the commercial reservoirs prove to be susceptible to waterflood it is apparent that considerable secondary reserves can be recovered in the Pennsylvanian conglomerate of the Central Kansas uplift.

When the primary production decline indicated that recovery would be on the low side of what is usually expected from a solution gas drive type reservoir, secondary recovery operations were considered.

A poorly defined pay section and a high interstitial water saturation, averaging over 40 percent of the pore volume, were detractions at the outset to success of the flood. Factors favoring the venture were a relatively high oil saturation before the initial injection and the low residual oil saturation anticipated at the flood's economic limit.

Through a closely-controlled pilot program and finally a pool-wide expansion, the project has been an operative and economic success. Oil recovery to date through waterflooding is approaching primary recovery; the remaining life of the flood is approximately three years.

Primary Recovery History

The discovery well in the Pennsylvanian conglomerate was Champlin Oil & Refining Company's Brungardt unit No. 11 well completed in July 1952. Initial production rate was 114 bbl of oil per day. This well and others drilled in the field also found the Toronto, Lansing-Kansas City, and Arbuckle formations productive. Primary development continued in the field until late 1953, when 19 wells had been completed.

Ultimate production development in the conglomerate indicated the reservoir enclosed some 1660 acre-ft in pay volume, with an area of about 237 acres and an average thickness of approximately seven feet.

Primary production declined at a rapid rate. It is estimated that ultimate primary recovery would be on the order of only 80 bbl of stock tank oil per acre-foot. This low recovery indicated that large volumes of oil would be left in place at primary depletion and in spite of the known high interstitial water concentrations the reservoir had definite possibilities as a prospective waterflood project.

Secondary Recovery Development

As the spacing for primary development was fairly uniform and some question existed as to the reaction of the reservoir to water injection, it was logically decided to pilot test an area of the conglomerate. The area selected for the pilot project was a five-spot development utilizing wells No. 1, 3, 5, and 9 for injection and well No. 4 as the producer (Fig. 1).

Before initiating injection, the three leases composing the pilot project were combined into a unit and on February 8, 1956, water injection was started.

The injection resulted in an almost simultaneous increase in production from wells in the pilot area. After approximately eight months of pilot operations it became apparent that the reservoir was susceptible to waterflooding, and also that water was migrating from the pilot area into other areas. Therefore, in November 1956, the entire area of the pool was converted to waterflood operations.

The conglomerate is considered to be fully drilled, and it is estimated that about 237 acres are being flooded. Possibly with the exception of converting one or two wells to injection service it is anticipated that the project will be produced to its economic limit with the existing completions.

Geology

The Pennsylvanian conglomerate in the pool is typical for the area. Core analysis described the formation as having fair porosity, between 13.8 and 18.4 percent, and with high water saturations in recovered cores ranging between 62.9 and 85.7 percent of the pore space. Residual oil saturation in cores was rather low, being between 6.4 and 15.2 percent of the pore space.

A structure map (Fig. 2) shows the reservoir is a local high along a west to east regional dip. The conglomerate

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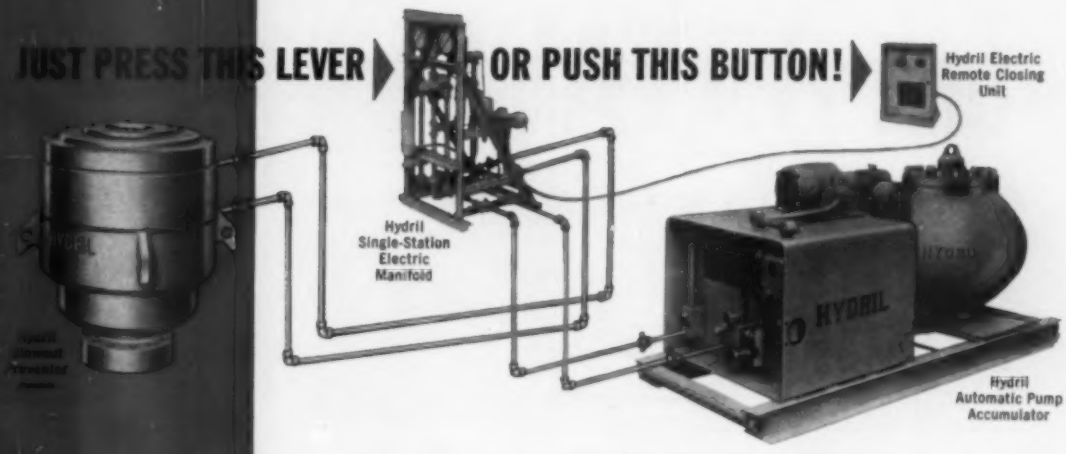
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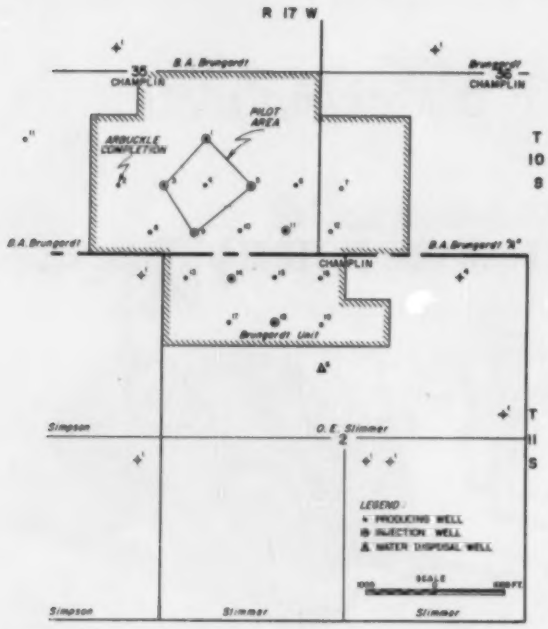

FIG. 1. Five-spot development in pilot project area utilizes wells No. 1, 3, 5, and 9 for injection and well No. 4 as the producer. Almost simultaneous increase in production resulted in the pilot area after water injection.

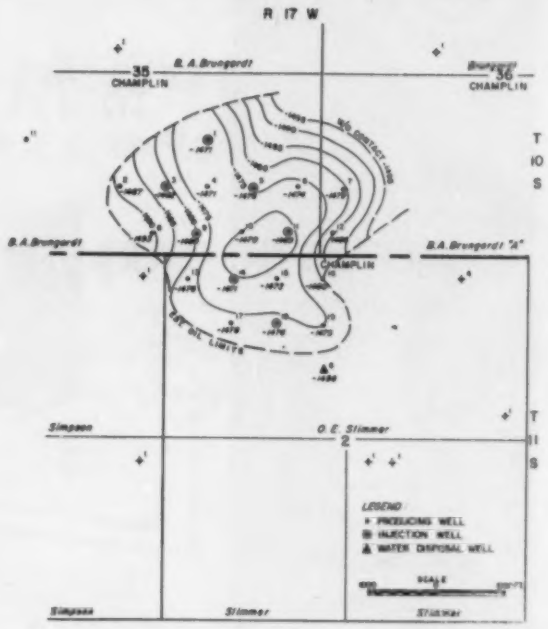

FIG. 2. Structure map shows reservoir is a local high along a west to east regional dip. Conglomerate section is about 70 ft in gross thickness. Water underlies the reservoir and has an average contact at about 1495 ft subsea.

is defined on gamma ray log surveys as a section about 70 ft in gross thickness. Water underlies the reservoir and has an average contact at about 1495 ft subsea.

Correlation of logs indicates some shale streaks found as unconformities within the productive section of the formation.

Reservoir Data

Core data from the reservoir rock is sparce. Correlation of available cores with gamma ray-neutron logs and drill stem test indicate the net pay isopach of the formation (Fig. 3).

Net pay thickness averages seven feet. Average horizontal permeability is 74 millidarcies and average vertical permeability is 39 md. Average porosity is thought to be about 14 percent.

As stated previously the interstitial water saturation was high, averaging in excess of 40 percent of the pore volume.

The top of the conglomerate is encountered at approximately 3400 ft from the surface at average conditions.

Producing Well Performance

Production from the seven wells in the conglomerate prior to flooding varied from about 2½ to 15 bbl of oil per

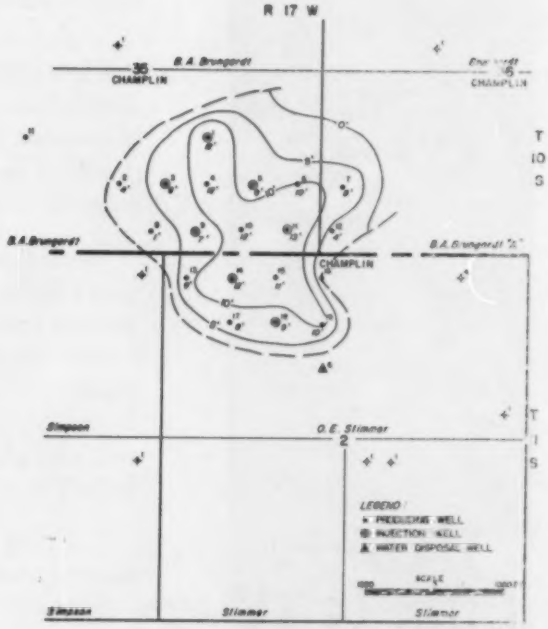

FIG. 3. Isopach of the formation shows net pay thickness averages seven feet. Average horizontal permeability is 74 md and average vertical permeability is 39 md. Average porosity is estimated at about 14 percent. Interstitial water saturation was high, averaging over 40 percent of the pore volume.

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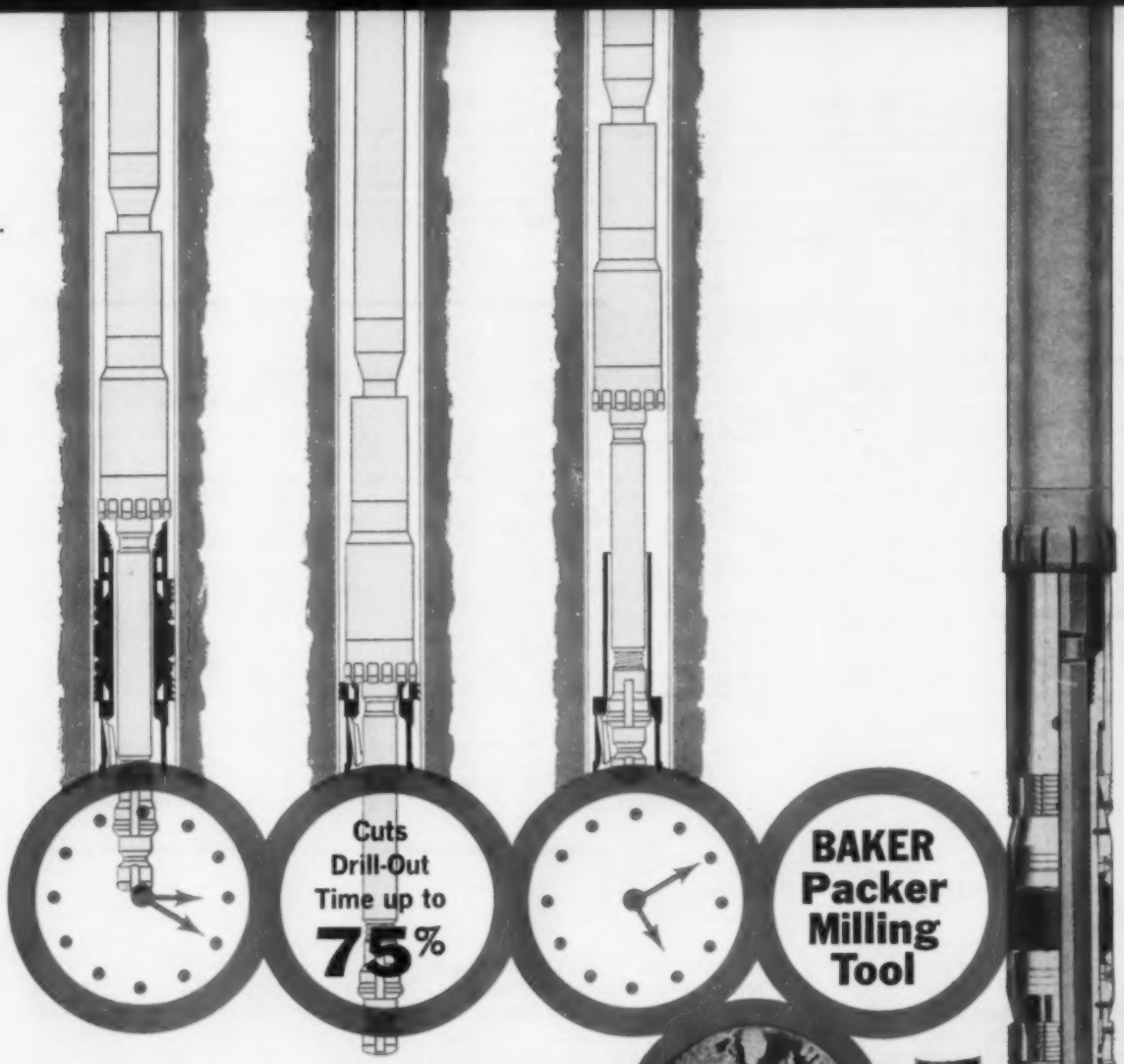

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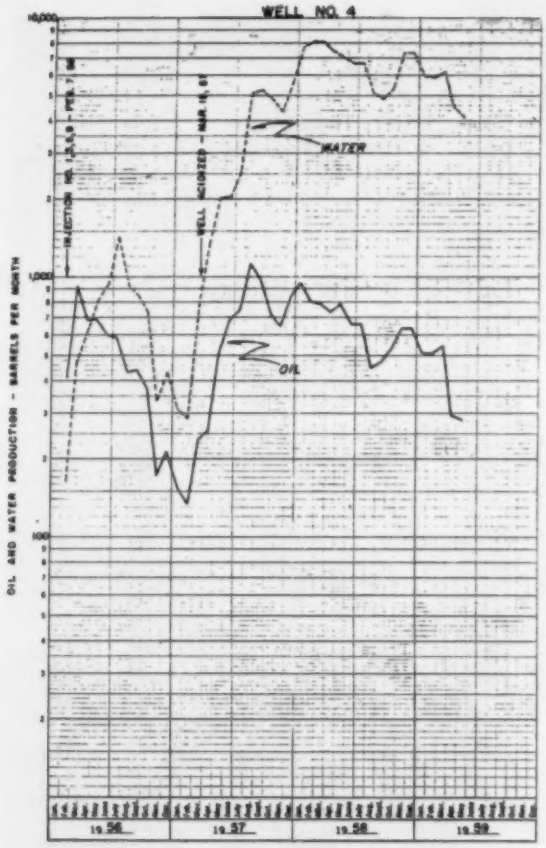

FIG. 4. Typical well performance curve shows well No. 6 had a slight production increase at outset of flood, but this gradually declined. Acid fracture of well's formation stimulated production. Drop in productivity was characteristic of most wells in reservoir, and precipitation of compounds in indigenous water may have caused this clogging.

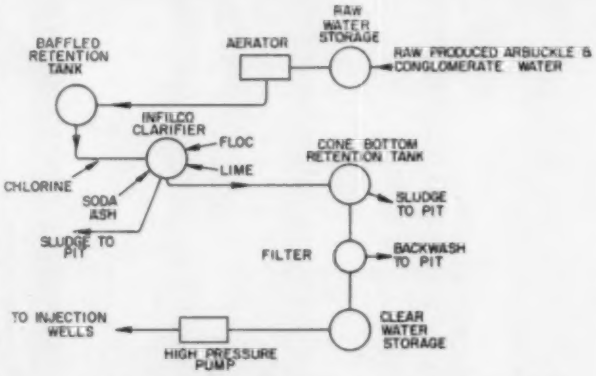

FIG. 5. Schematic diagram shows stages of treatment used in stabilizing and clarifying the water before injection. Raw mixture of produced water from Pennsylvanian conglomerate and Arbuckle formation is laden with dissolved hydrogen sulfide. As water recirculates, amount of dissolved chemicals changes.

day. Total production prior to flooding was 50 bbl of oil per day.

Water production in these wells prior to flooding varied from 2½ bbl per day to 15. Overall water production was 35 bbl per day.

Production since injection has varied widely from well to well. A typical well performance curve (Fig. 4) indicates well No. 6, an outside producer on the east side of the pilot, showed a slight production increase at the outset of the flood but gradually declined in productivity. A careful study of the well in 1958 indicated that the productivity was retarded by sandface plugging. An acid fracture of the formation in this well has stimulated production to its present level of about 19 bbl of oil per day.

A drop in productivity has been a characteristic of most producing wells in the reservoir, and it is thought that condition has been brought about by precipitation of plugging compounds found in the indigenous water produced during the injection waters' encroachment toward the well bores. When injection water breaks through in a well the plugging action is minimized.

Revitalizing productivity in wells that have been affected by the plugging action has been accomplished through acidizing or fracture treatment.

Injection Wells

Injection wells are conventional in most respects. Pipe is set through the formation and three to six perforation shots per foot open the casing to the reservoir.

Only exceptions are wells which were opened to the Lansing-Kansas City formation before being opened into the deeper Pennsylvanian conglomerate. These wells have a retainer-type packer set between the Lansing-Kansas City and the conglomerate. At such time as the waterflood in the conglomerate is terminated, the wells will be ready for a waterflood project in the Lansing-Kansas City with a minimum amount of expense.

Injection Water

Arbuckle formation water along with water produced from the conglomerate is used for displacement. The Arbuckle water originates as a by-product of other oil producing wells in the unit area.

The raw mixture of injection water is laden with dissolved hydrogen sulfide. A schematic diagram (Fig. 5) shows the stages of treatment used in stabilizing and clarifying the water.

Initial treatment involves passing the water through a forced-draft aerator. The aerated water is then delivered to a baffled retention tank. Experience has indicated that the water after aeration requires retention to allow the reaction between oxygen, hydrogen sulfide, and other complex sulfur compounds to progress toward completion. The retention time is about 12 hours.

The water is then fed toward a clarifier. At the entrance to the clarifier the water is treated with chlorine. The chlorine is utilized both as a reacting agent to remove any remaining hydrogen sulfide traces and as a bactericide in sterilizing the water.

Ferric chloride, lime, and soda ash are added to the clarifier. The water is then sent to a cone-bottom retention tank where impurities settle for about eight hours. The water is then sent to a pressure type filter and the effluent is discharged to the clear water storage. A typical analysis of the raw water and injection water after treatment is shown in Table 1.

Treatment of the water has varied considerably through the history of the flood. During the course of the project, it has been found that the requirements of treatment have become more

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TABLE 1. Analysis of Raw and Treated Water.

	Raw Water	*Treated Water*
Specific gravity, 60 F	1.038	1.038
pH	6.8	7.3
Total alkalinity as HCO_3, ppm	464	254
Supersaturation as $CaCO_3$, ppm	4	6
Calcium as Ca, ppm	2,967	2,713
Magnesium as Mg, ppm	772	692
Sodium as Na, ppm	22,380	19,588
Sulfate as SO_4, ppm	1,035	915
Barium as Ba, ppm	0	0
Chloride as Cl, ppm	34,200	36,252
Silica as Sio_2, ppm	8	12
Iron as Fe, ppm	10	3
Manganese as Mn, ppm	0.3	0.3
Turbidity Electric, ppm	27.0	2.5
Color as Pt, ppm	45.0	3.0
CO_2 calculated, ppm	126.0	21.0
Hydrogen Sulfide, ppm	47.5	0

TABLE 2. Statistical Data.
JUNE 1, 1959

Date of first water injection	February 7, 1956
Cumulative water injection, bbl	725,000
Cumulative waterflood oil production, bbl	142,000
Cumulative water production since injection, bbl	524,000
Cumulative produced water-oil ratio	3.69
Cumulative injected water-oil ratio	5.11
Waterflood oil recovery, bbl/acre-ft	85.5

severe and costly. The appearance of injection water in producing wells and its subsequent reinjection has appreciably changed the composition of chemicals dissolved in the water. This, in turn, has been responsible for the varying water treatment program.

FIG. 6. Overall performance history of primary and secondary oil production shows rate prior to flooding had declined to about 50 bbl per day. Increase during December 1958 was attributed to treatment in other producing wells and reworking the Arbuckle well into the conglomerate.

Waterflood Performance

An overall performance history of the project's primary and secondary oil production (Fig. 6) shows the rate prior to flooding had declined to about 50 bbl per day.

The peak secondary production period was in September 1957 when the daily average was almost 195 bbl of oil. The increase in rate during December 1958, is attributed to reworking an Arbuckle well into the conglomerate and also response to treatment in other producing wells.

Oil production in May 1959 averaged about 142 bbl per day and water production had increased to some 679 bbl per day.

Cumulative oil production attributed to the waterflood is estimated at 142,000 bbl as of June 1, 1959. Cumulative water production during the life of the project has been 524,000 bbl. (Table 2.)

Conclusion

This waterflood project in the Pennsylvanian conglomerate formation in Kansas has proved to be an economic and operational success. Secondary recovery operations in the Brungardt field have, to date, resulted in an estimated recovery of 142,000 bbl of oil that would not have been otherwise recovered. The trends in production also show that considerable oil remains to be produced through waterflooding the reservoir to its economic limit, which is some three years away. ★ ★ ★

Edgar L. Leissner is a senior petroleum engineer in the secondary recovery section of Champlin Oil & Refining Company, and has held this position for three years. Previously, he was assigned to the company's Stratton district and Texas division offices.

He was with Warren Petroleum Corporation Research Laboratory from 1950–53, and Southern Alkali Corporation from 1953–55.

Leissner was educated at Texas College of Arts and Industries, and received a BS degree in chemical engineering in 1948 and an MS degree in 1949.

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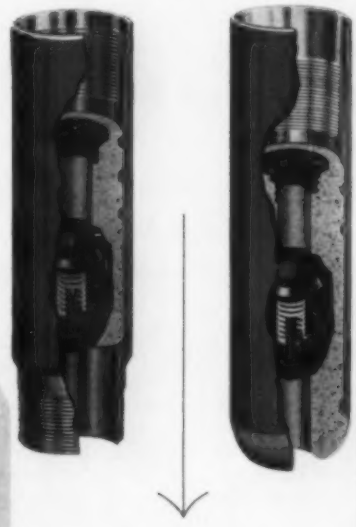

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Gas-Condensate Reservoirs

***Part 7** of a continuing series on gas condensate reservoirs discusses "fair market value" and some of the many factors necessary to consider in determining this factor*

William C. Goodson, *Republic Natural Gas Company, Dallas, Texas*

IN PREVIOUS INSTALLMENTS of this series, the cost of exploration and field development, the gas contract principles, the gathering system and field processing design, gasoline plant feasibility, field operational problems, unitization aspects, and deliverability or availability of the reserves have all been given due consideration. In this particular article fair market value will be defined and some of the economic factors that enter into its determination will be discussed.

Fair Market Value

Fair market value has been defined by Paine in *Oil Property Valuation* as "the price at which the property would be sold by a willing seller to a willing buyer, neither being under any compulsion to buy or sell, and both being competent and having a reasonable knowledge of the facts." This definition is straightforward enough, however, the last phrase "having a reasonable knowledge of the facts" is the bugaboo. What will be done in the limited space in this article is to discuss some of the "facts" that should be analyzed by both parties — buyer and seller — in arriving at a mutually agreed upon "fair market value." It will be impossible to develop within this article sufficient knowledge of the factors of tax, risk, percentage depletion, economic life, salvage, governmental regulation, discount values, and other items to have the depth and breadth that come with prolonged experience and judgment. Possibly discussing some of these factors and giving reference to more detailed treatment and refinement will be sufficient incentive for further study.

Taxation In All Its Aspects

The aspects of taxation and all its many facets is an undertaking much beyond the scope of this study. Only some of the tax problems that beset operators in the acquisition of properties, drilling, development and operation of the properties, and possible ultimate disposal will be mentioned.

The handling of taxes is best done by someone engaged exclusively in that phase of the endeavor, but appraisers and valuation engineers must be cognizant of some of the more familiar tax concepts. For more detail on all tax matters, the reader is urged to consult Breeding and Burton's treatise on Oil and Gas Taxation.

In the drilling operation, the salient features afforded by the option to expense intangible drilling expenses should be set out by the valuation engineer. The differentials between the items that must be capitalized and those that can be expensed can afford a considerable tax saving to an operating or producing company.

Some of the ideas developed and discussed by Breeding in his article "Effect of Taxation on Valuation and Production Engineering" presented at the AIME Valuation Symposium in 1956 are:

1. The property unit
2. Depletion — both cost and statutory
3. Capitalized lease costs
4. Intangibles
5. Conveyances

The taxation of oil and gas is an extremely complex subject, but one which affects every oil and gas operator. It is possible to carry out transactions by many different methods, which while arriving at the same end point may result in widely diverse tax structures. For this reason, the petroleum operator needs either to be familiar with the basic tax laws and their constant changes or to have competent tax counsel.

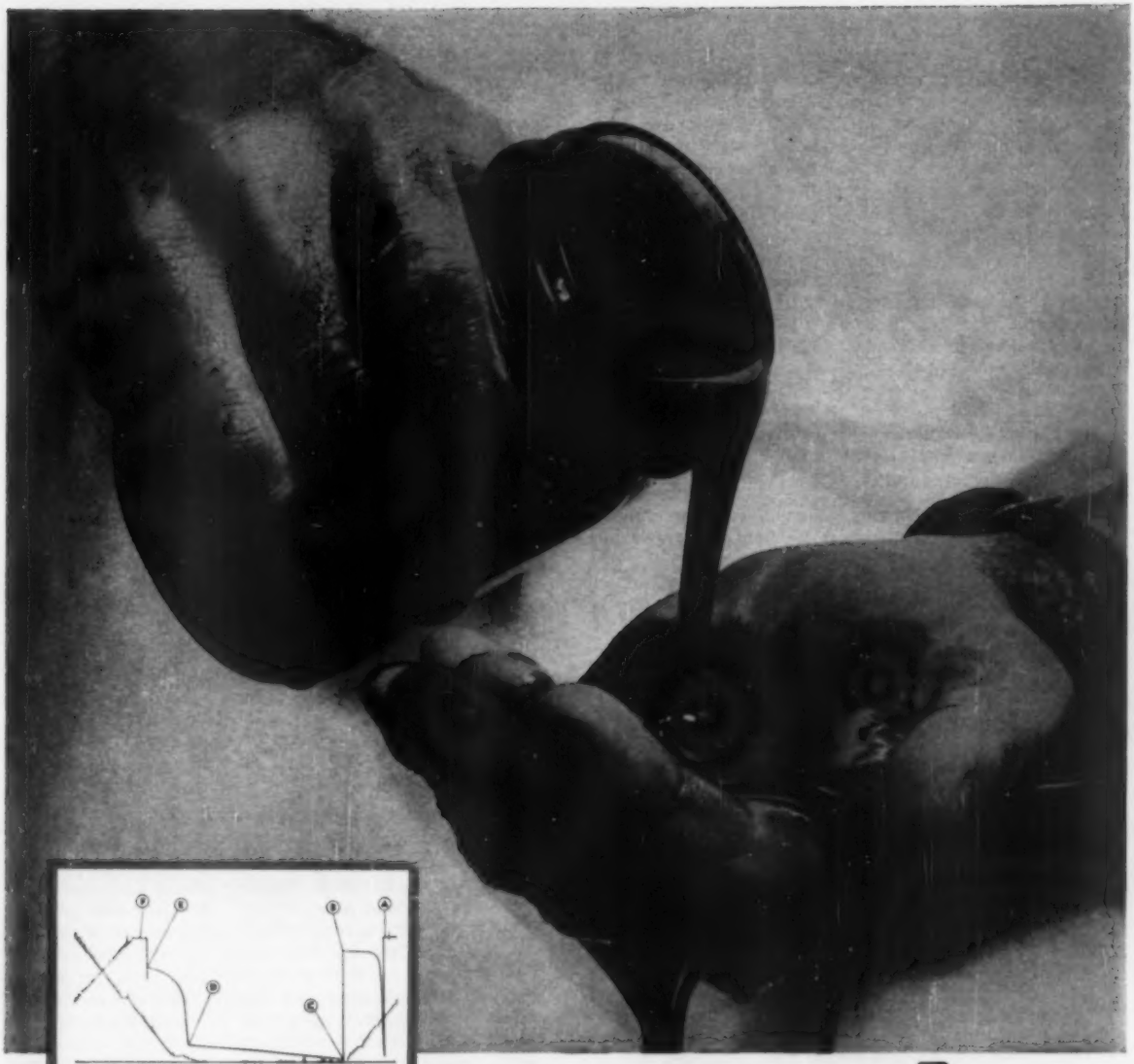
Percentage Depletion

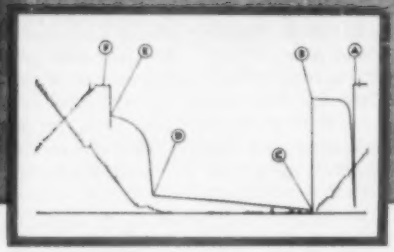
All oil people, regardless of their position, have heard and are familiar at least vaguely with the term *percentage depletion.* So much has been written on this subject that further mention may be belaboring the issue. However, the importance of this fundamental provision of our depletion of natural resources is something that must be protected.

First let us understand that this is not a tax loophole or favor to make oil millionnaires. In fact it is not even limited to producers of oil and gas. On the contrary, it applies to all producers of exhaustible natural resources in differing amounts.

The government has no more right to deny a depletion deduction to be charged against the gross receipts of the oil producers than it would have to take an individual's farm for use as a military airfield without paying for it.

The limitation of fifty percent of net income and no allowance for gasoline or processing income are limitations enough on this provision. In actuality, instead of eliminating or reducing this 27½ percent depletion provision all effort should be expended to increase this value in light of the increased risks in oil and gas exploration. It is also important to remember that percentage depletion is only an option; i.e., in cases where cost depletion gives a greater deduction it is used rather than percentage depletion.





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Depreciation

Depreciation may be defined as the physical deterioration caused by wear and tear of the action of the elements, and resulting in an impairment of the operating effectiveness. Depletion, as discussed in the previous paragraphs, differs from depreciation in that it represents the exhaustion of a wasting asset, a matter of reduction in quantity.

Again it must be emphasized that a thorough coverage of the subject — depreciation — would require several entire volumes. The type or concept used in evaluating depreciation may have an important role in affecting a particular plant or project's attractiveness.

John E. Arens in his article "Depreciation," *The Petroleum Engineer*, p. E-12, July 15, 1956, describes the four different basic concepts that help clarify depreciation. They are:

1. Decline in value
2. Amortized cost
3. Appraisal concept
4. Impaired utility

Concrete business decisions depend upon the proper selection of the concept of depreciation which is applicable to the case at hand.

B. J. Gaffney in an article, "Which Depreciation Method Is Best," *Petroleum Refiner*, December 1957 states that it is up to the owner or operator and the government to establish jointly a reasonable basis for handling depreciation. Some of the depreciation methods that might be used are:

1. Straight line method
2. Declining balance method
3. Sum of the digits method

The straight line method provides that the cost of equipment, less salvage value, be depreciated in equal amounts over the useful life of the equipment.

The declining balance method provides that a uniform percentage of depreciation be applied to the unrecovered cost of the equipment, without regard to salvage value.

The percentage depreciation shall not exceed twice that of the straight line method. This method will never result in a zero balance.

The sum of the digits method provides that the annual amounts of depreciation be computed by a changing fraction to the cost of the equipment. The numerator will be the years of useful life remaining. The denominator will be the sum of the years of estimated useful life.

A composite example might help clarify these three methods. This is given in Table I.

With the declining balance method and sum of the digits method, it can be seen the accrued depreciation is 60 percent or more in two years and over 78 percent in three years. The effects of accelerated depreciation can convert a project of poor possibility into a highly profitable or attractive investment opportunity.

This idea of depreciation is probably one of the most controversial items facing petroleum operators and all other business men in the preparation of their annual income tax return. In a recent report bulletin from the Federal Branch Reserve Bank of Chicago it was reported that depreciation allowance taken by corporations had increased from $5.2 billion in 1947 to $16.7 billion in 1956. Depreciation plays an important part in computing costs and taxable income. It also contributes substantially to cash flow and to replacement and expansion funds.

Table I. Comparison of Three Methods of Depreciation.

A. Straight Line Method

Amount to be depreciated = $10,000
Estimated useful life = 5 years

Year	Amount to be depreciated	Percent depreciation	Amount of depreciation	Cumulative depreciation	Cumulative percent
1	$10,000	20	$2,000	$ 2,000	20
2	10,000	20	2,000	4,000	40
3	10,000	20	2,000	6,000	60
4	10,000	20	2,000	8,000	80
5	10,000	20	2,000	10,000	100

B. Declining Balance Method

Amount to be depreciated = $10,000
Estimated useful life = 5 years

Year	Amount to be depreciated	Percent depreciation	Amount of depreciation	Cumulative depreciation	Cumulative percent
1	$10,000	40	$4,000	$4,000	40.0
2	6,000	40	2,400	6,400	64.0
3	3,600	40	1,440	7,840	78.4
4	2,160	40	864	8,704	87.0
5	1,296	40	518	9,222	92.2
	Balance 778				

C. Sum of the Digits Method

Amount to be depreciated = $10,000
Estimated useful life = 5 years
Sum of the year = 1 + 2 + 3 + 4 + 5 = 15 Years

Year	Amount to be depreciated	Depreciation fraction	Amount of depreciation	Cumulative depreciation	Cumulative percent
1	$10,000	5/15	$3,333	$ 3,333	33.3
2	10,000	4/15	2,667	6,000	60.0
3	10,000	3/15	2,000	8,000	80.0
4	10,000	2/15	1,333	9,333	93.3
5	10,000	1/15	667	10,000	100.0

Inflation

Originally and still to a large extent cost comparisons are based on a dollar of constant value. The facts particularly since World War II are that the time value of the dollar decays year by year. F. C. Jelen has prepared a detailed article on "How Inflation Affects Cost Analysis," *Petroleum Refiner*, August 1958. The basic fact brought out in this article is simply that a piece of equipment that will cost C dollars now will cost C $(1 + d)$ dollars in one year, or C $(1 + d)^n$ n years from now. d is the annual inflation rate expressed as a fraction. This assumed rate d can be included in all manner of cost comparison calculations. This in itself is a non-controllable risk factor and indications are strong that suggest the continuation of the trend.

Risks Involved In Petroleum Evaluations

There are risks involved in all business ventures. In our particular business there is no rated comparison between the investment decisions necessary for oil and gas production with that of other industries. With most manufacturing enterprises an investor can expect a facility of predictable size for capacity for a given capital expenditure. The investor in the oil and gas business has no such assurance. On the average only one wildcat well in nine will produce any oil or gas. With these type odds against him an oil or gas investor must be an intrepid soul.

It is not within the purview of this paper to quantitatively evaluate all the risk factors that go into oil or gas exploration or production. Fortunately for those vitally interested in this aspect of the evaluation procedure, several excellent theses and studies have recently been prepared that will prove of great benefit in evaluating and minimizing the inherent risks in petroleum ventures.

To my mind the most definitive and quantitative work to date on this subject is the doctorate thesis of Charles J. Grayson, Jr. This work was sponsored somewhat by the Independent Petroleum Association of America and done

as a research project of Harvard Business School. Dr. Grayson is now following up his thesis with a book on the risks particularly in exploration ventures. His thesis of over 400 pages was divided into two primary parts.

The first part was devoted to an analysis and examination of the nature and characteristics of risk in petroleum production. This involved a study of the economics of petroleum production, statistics relative to dry and productive exploratory and development wells, cost depth relationship, tax provisions unique to petroleum production regulatory factors, and any other pertinent information that tended to throw light on the risks faced by petroleum producers.

The second part of Grayson's study involved actual field research and analysis of the research. He visited many independent producers in Texas, Oklahoma, and Louisiana to obtain information about specific situations as to how risks are appraised and what factors are most important in evaluating those risks. These case studies formed the major portion of his thesis and will further form the major portion of his forthcoming book. His comprehensive study is the first truly quantitative step in attempting to tie together the many variables that are inherent in petroleum risk decisions.

Another thesis that was published in early 1959 goes a long way in enumerating and defining the controllable and non-controllable risk factors in the formation of an oil company. This thesis was also sponsored somewhat by the IPAA and was jointly done by Murray Allan Bennett and John J. Schary, Jr. at Pennsylvania State University. This thesis is entitled "The Assessment and Reduction of Risks in the Formation of an Oil Producing Company" and a free copy may be obtained by writing IPAA Information Service, Box 1019, Tulsa, Oklahoma.

This particular thesis is broken down into three primary parts — non-controllable risks, reducible risks, and the spreading and sharing of the reducible risks.

Non-controllable risks were classified into four main categories: (1) Effect of general economic forces on the industry, (2) Nature of the problems that currently affect this industry, (3) Possible disposition of these problems in the future, and (4) General prospects for the future.

Reducible risks are risks that can not only be evaluated beforehand but can be reduced to such an extent that the chances for success are materially increased. Some of these reducible risks are caliber and reputation of the promoter and managers, division of managerial functions, choice of an operational policy, selection of an organization structure, selection of a financial structure, choice of financing methods, methods by which assets are acquired, use of capital, use of income, and approach to exploration activities.

One key point that is continuously stressed is that the seeking of the best geological advise is the cheapest investment an oil company can make.

Sharing and spreading the risks with other operators is a most logical procedure even though a smaller share accrues to each of the parties. This spreading or sharing of exploration or production risks may be accomplished by (1) Dry hole contribution, (2) Bottom hole contribution, (3) Acreage purchase agreement, (4) Joint interest wells, (5) Sharing risk with the drilling contractor, (6) Farmout to others, (7) Stock interest in other producers, and (8) Merger with other producers.

F. B. Odasz, Jr. in his article on "How to Make Better Decisions" from *Oil and Gas Equipment*, January 1957, points out the essential role that statistics and probability play in making successful decisions. These principles are applicable to a far greater variety of situations than are the mere techniques and calculations of statistics. These techniques are particularly valuable in comparing alternate investment possibilities.

R. S. Wansbrough of Delhi-Taylor at the fall meeting of the AIME in Dallas in his paper entitled "An Approach to the Evaluation of Oil Production Capital Investment Risks" developed the technique of applying probabilities and relative probabilities to drilling projects with several prospective producing sands. This treatment of risk requires that specific estimates of risk be attributed to each aspect of a particular project.

All of the above mentioned articles and many more are attempting to quantify the risks that petroleum investors continuously face. The use of their developed techniques should aid petroleum appraisers and valuation engineers in their property acquisition studies.

Regulatory Climate In Washington

For producers, the control of natural gas and the operations of the Federal Power Commission are always a factor in major gas transactions. Recently an article in a leading business magazine made a vitriolic attack on the FPC and its lack of action in performing the duties of regulating producers.

The attack was grossly unfair and obviously only looked at the problem from one side. In actuality the FPC has been doing a momentous job since 1954 with only a slight increase in their staff. Some of their recent decisions that bear close study are (1) CATCO case and the action of the Supreme Court, (2) The Transwestern decision, and (3) Zwerdling's analysis of the Phillips case and the rehearing of the examiner's decision.

All of these cases and others are tending to build a backlog of cases that can possibly be used in further rate cases.

The idea of area pricing seems to be getting some definite consideration by the Commission.

There again is some talk of a new gas bill to come before Congress. Since the original Phillips Decision of June 7, 1954, by the Supreme Court, the confusion in the natural gas business has been greatly compounded by the producers being placed under a regulatory blanket that was intended for established utilities and had never been applied to the risks of gas exploration and production.

The appraisers in the gas business should be cognizant of the trends in gas regulation and take this into account in formulating their investment decisions.

Present Worth Applications

All property evaluation is based on determining the possible purchase price which will yield a given rate of return on an investment. An evaluation engineer must use several rates of return or discount factors to enable management to have a range of conditions upon which to base their decisions. There are many investment yardsticks that are currently being used and discussed in the technical and economic literature.

Some of these yardsticks are: (1) Rate of return, (2) average annual profit, (3) rate of return by the discounted cash flow method, (4) time to payout capital investment, (5) remaining income after payment of investment, (6) profit to investment ratio, (7) present value profit and many others.

At least a good portion of these make use of compound interest in one form or another. Many banking institutions, companies, and consultants have set yardsticks that determine whether or not they will engage in a given venture. John Arps in a speech before the AIME Study Group in Dallas, Texas, October 1956, outlined some of these as follows:

1. 50 percent future net earnings before depreciation and taxes discounted at 5½ percent.
2. Same as above, except discounted at 4 percent.
3. Same as above, undiscounted.

4. Future net income before depreciation but after taxes and overhead discounted at 8 percent.
5. ⅔ future net earnings, before depreciation and taxes discounted at 5 percent.
6. 75 percent of future net earnings before depreciation and taxes but after overhead discounted at 6 percent.

These are a sampling of some of the methods used. Obviously there are many variations to these methods. All except number 3 use some discount factor. Interest may be compounded in several different manners: annually, semi-annually, quarterly, or continuously.

The selection of rate and compounding period is usually left to the discretion of the appraiser, but for comparison purposes the same compounding period should be used in all cases. Generally, as a useable compromise, semi-annual compounding is used. This is not to rule out the other methods, however.

Two methods that are being used to a great extent that also make use of discounting principles are *the average annual profit method and the rate of return by the discounted cash flow method.*

Average annual profit method. This method makes use of two interest rates — one a safer rate of interest at which money is valued and the other a speculative value or average annual profit expressed as a fraction. This may be expressed as an equation:

$$AAP = \frac{r}{(1 - ADF)} \left[\frac{DI - CI}{CI} \right]$$

where:

AAP = Average annual profit, percent
r = Money value, percent
DI = Deferred Income, dollars at rate r
CI = Capital Investment, dollars

For example: If $100,000 earns $300,000 in 20 years in equal increments and money is valued at 6 percent, what is the average annual profit?

$$AAP = \frac{6}{1 - 0.58423} \left[\frac{(0.58423)\ (300{,}000) - 100{,}000}{100{,}000} \right]$$

$$= \frac{6}{0.41577} \left[\frac{175{,}269 - 100{,}000}{100{,}000} \right]$$

$$= (14.42)\ (0.75269) = 10.85 \text{ percent}$$

Rate of return by the discounted cash flow method. This method of investment evaluation makes the assumption that a purchaser is buying a series of *future annual incomes.* This type of calculation involves finding the interest rate by trial and error computations which discount the future earnings of a proposal to a present value just equal to the capital investment of the proposal. This can be expressed mathematically by the following equation:

$$\sum_{n=0}^{n=n} \frac{An}{(1+i)^n} = 0$$

where:

An = cash flow each year
i = rate of return

The time rate of the investment and the future cash flow is given proper weight, by this method. The annual rate of return, computed by the discounted cash flow method, with proper consideration of income taxes probably represents the most realistic and convenient yardstick for evaluation comparison.

Table 2 is an example of this method using a 15¢ contract for a 20 year life and a proposed purchase price of $12,000,000 for a property with a constant cash flow as given.

Table 2. Discounted Cash Flow Method.

Rate of Return on Purchase Price of $12.00 MM for 15¢ Contract, 20 year life.

An annual cash flow		Trial Rate			
	(MM$)	$R_1 = 15\%$* Factors	Value (MM$)	R = 14%* Factors	Value (MM$)
0-0	12.0000	1.0000	12.000	1.0000	12.000
0-1	1.7435	0.9348	1.630	0.9386	1.636
1-2	1.7435	0.8128	1.420	0.8234	1.435
2-3	1.7435	0.7068	1.235	0.7222	1.260
3-4	1.7435	0.6141	1.070	0.6335	1.105
4-5	1.7435	0.5034	0.877	0.5552	0.970
5-6	1.7435	0.4647	0.810	0.4874	0.851
6-7	1.7435	0.4036	0.705	0.4275	0.746
7-8	1.7435	0.3514	0.612	0.3750	0.655
8-9	1.7435	0.3055	0.533	0.3290	0.574
9-10	1.7435	0.2656	0.462	0.2886	0.504
10-11	1.7435	0.2310	0.403	0.2529	0.442
11-12	1.7435	0.2009	0.350	0.2216	0.377
12-13	1.7435	0.1747	0.304	0.1948	0.340
13-14	1.7435	0.1519	0.264	0.1709	0.298
14-15	1.7435	0.1321	0.230	0.1499	0.262
15-16	1.7435	0.1148	0.200	0.1315	0.230
16-17	1.7435	0.0999	0.174	0.1153	0.201
17-18	1.7435	0.0869	0.152	0.1007	0.176
18-19	1.7435	0.0755	0.132	0.0887	0.155
19-20	1.7435	0.0657	0.105	0.0778	0.136
			$-0.432(V_1)$		$+0.223(V)$

$$\text{Rate of Return} = R + \frac{V(R_1 - R)}{(V - V_1)} = 14 + \frac{0.223\ (15 - 14)}{[0.223 - (-0.432)]}$$

$$= 14 + \frac{(0.233)}{0.655} = 14.34 \text{ percent}$$

*Baxter, C. H., and Parks, R. D., "Mine Examination and Valuation." Second Edition — 1939, Michigan College of Mining and Technology.

The *discounted cash flow method* has the following superiorities over the other methods:

1. It is economically realistic in confining the analysis to cash flows and forgetting about customary book allocations.
2. It forces guided thinking about the whole life of the project and concentration on the lifetime earnings.
3. It weights the time pattern of the investment outlay and the cash earnings from that outlay in such a way as to reflect real and important differences in the value of near and distant cash flows.
4. It reflects accurately and without ambiguity the timing of tax savings.
5. It permits simple allowances for risks and uncertainties.
6. It is strictly comparable to cost-of-capital ratios so that decisions can be made quickly and safely on the basis of the relationship between initiated rate of return and value of money to the company.

There are other modifications of the rate of return by the discounted cash flow method. Woody and Capshaw of Humble in the 1959 Fall Meeting of the Society of Petroleum Engineers presented a paper entitled "Investment Evaluation by the Present Value Profile." Their method relates present value profit against discount rate in what is termed a "present value profile." By use of this yardstick and possibly the rate of return by the discounted cash flow value, management may be able to assign cash profit an index of attractiveness.

In the next installment of this article a series of charts

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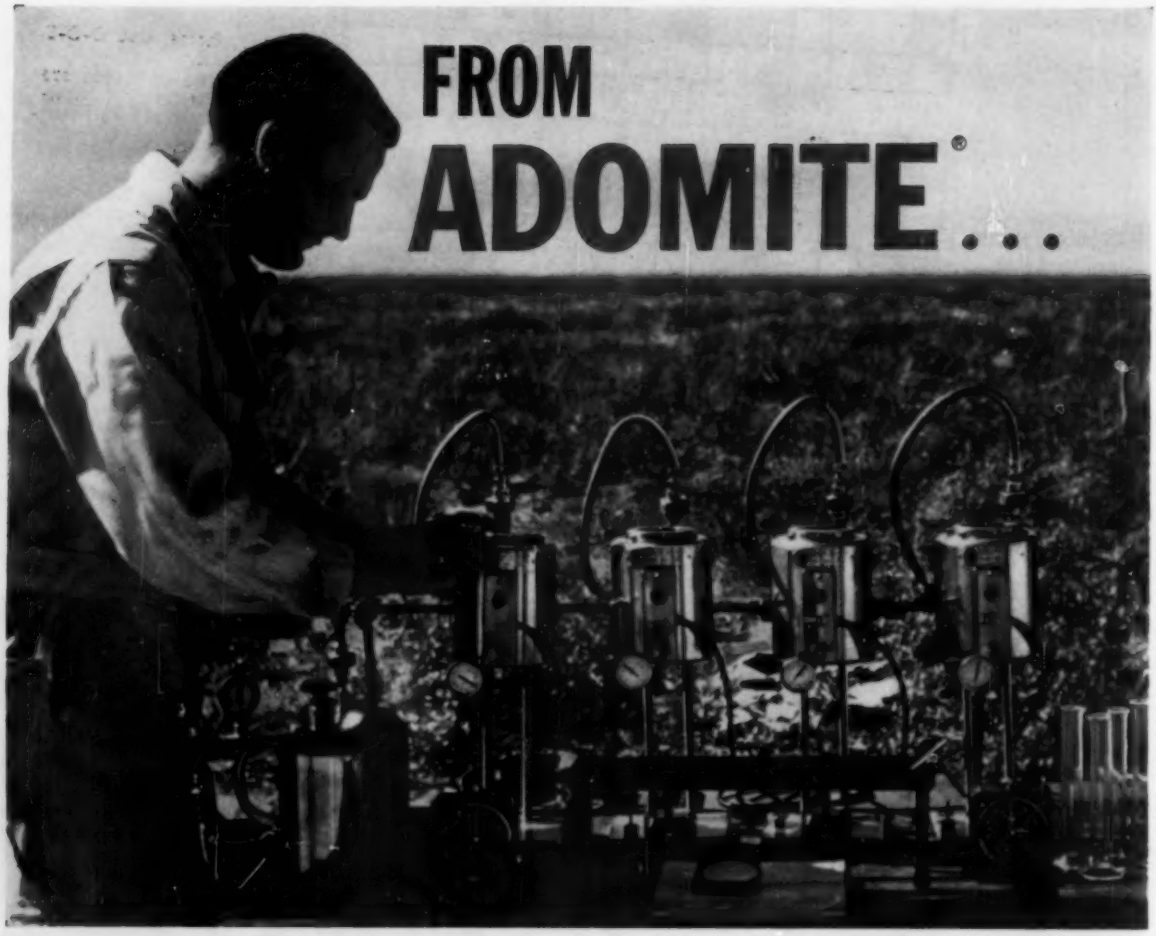

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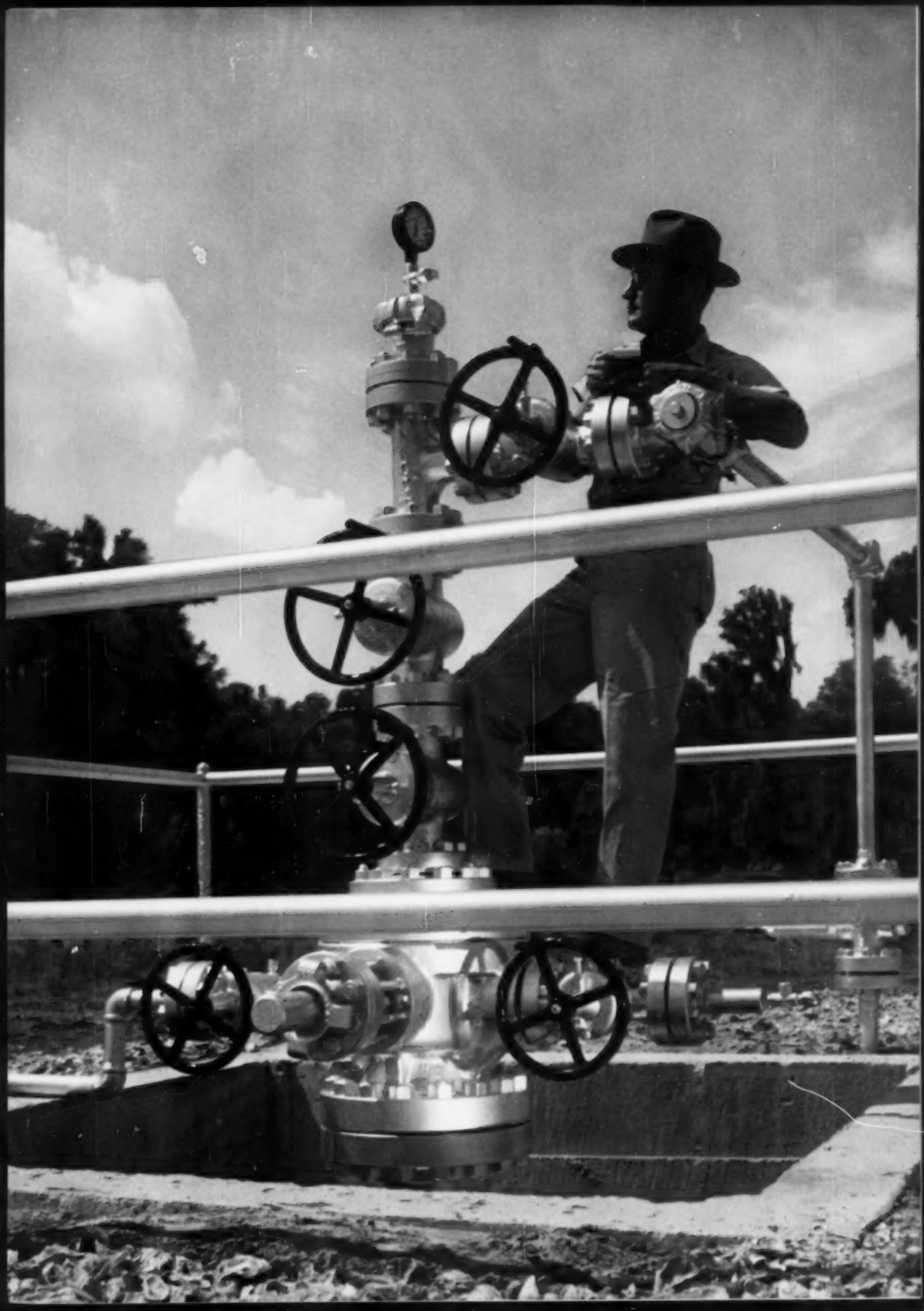

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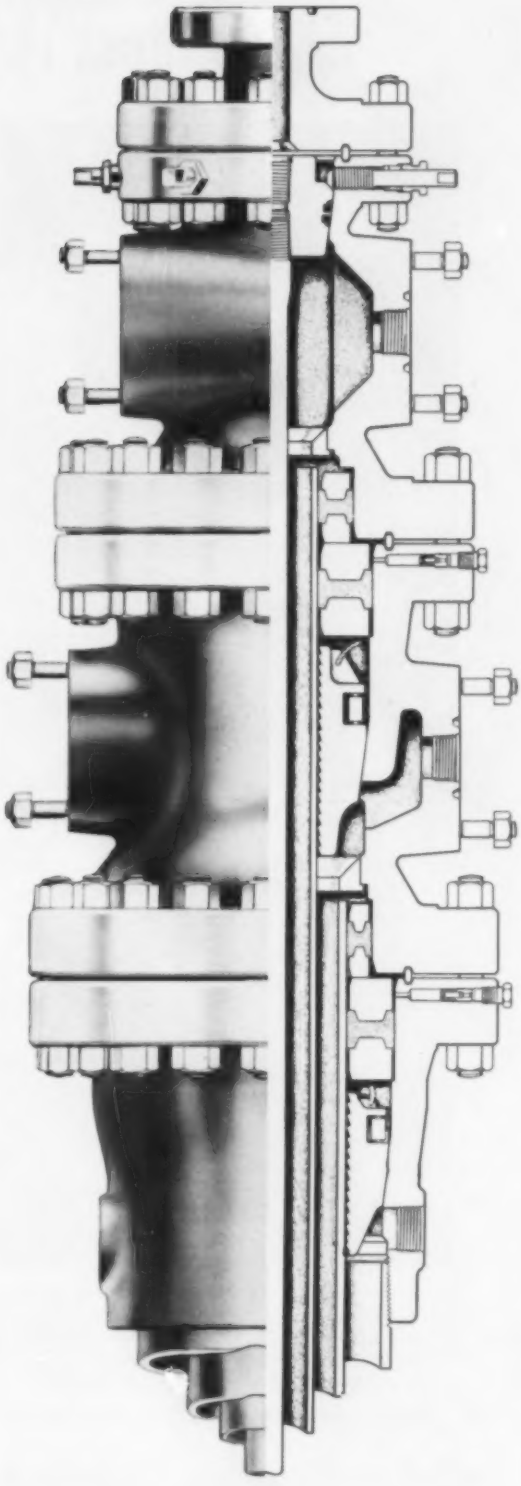
More on the next page



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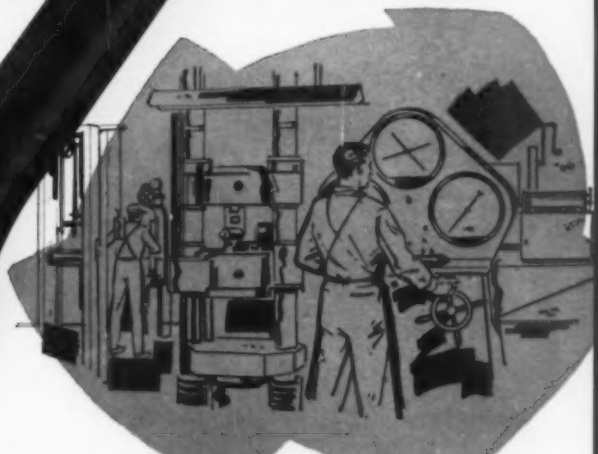

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Methods of Financing

After performing all the necessary evaluation functions including the discounting procedures outlined above, the final question becomes apparent. Where and how is the project going to be financed?

Lyon Terry and Kenneth Hill in a pamphlet published by the Chase Manhattan Bank discussed three possible methods that might be used: (1) Purchase for cash, (2) Purchase financed by direct loan, or (3) Purchase by use of an oil payment.

Another factor that is discussed is the safety factor that banks require. Generally this is between 60 percent and 70 percent of the estimated value of the property.

A special form of the purchase by use of an oil payment is the so-called ABC method. The advantages of this method to the purchaser are so strong that few property acquisitions are made without the use of a reserved production payment. Harold Hammer in *The Petroleum Engineer* in December, 1954 made a simplified explanation of how the ABC plan works without too many details:

"1. The Seller, "A," divests himself of all right, title, and interest in the asset and, for tax purposes, effectuates a capital gain on the sale.

2. The bank-loan, if any, obtained by the holder "B" of the oil payment will normally be completely liquidated by oil-runs from the property.

3. As the oil-runs to "B" are applied against the bank-loan, "B's" interest is eventually extinguished.

4. The purchaser "C" is not chargeable, for income tax purposes, with constructive receipt of the monies or oil passing directly to "B."

5. Through this means of diverting income from the property to pay off the bank-loan and the oil-payment, "C" has acquired the seller's interest at a minimal out-of-pocket cost.

6. After liquidation of oil payment, "C's" interest is complete and unencumbered, and he receives 100 percent of income, subject to depletion.

7. Thus, "C" is in position to realize a long-term capital gain, measured against his low-cost basis (and, like "A," may then effectuate another "A-B-C" type transaction, if he so desires)."

Other Factors Affecting The Natural Gas Business

In addition, there are other factors that will definitely affect the natural gas business in the near future. One of these factors is the increased demand for helium as reflected by the government's recent proposal for twelve new plants. The government is also attempting to bring private enterprise into these helium plant construction projects.

Another factor that may have far reaching consequences is the liquefaction, storage, and shipping of natural gas. The initial successful voyage of the Methane Pioneer to England in February, 1959 opens many new horizons for natural gas. This is a factor that bears close scrutiny in future economic forecasting.

The coal people are making a concerted effort to undermine natural gas and to keep the markets for natural gas consumption from expanding. They continuously intervene before the FPC on any new attempt to expand by natural gas companies. Their efforts to set up a National Energy policy should be carefully watched and guarded against.

INDEPENDENT ADVOCATES MANDATORY POOLING

A NEW STATE LAW which would require mandatory pooling on established spacing patterns in Texas oil and gas fields was advocated by Michel T. Halbouty, Houston independent oilman, in a recent speech before the annual joint meeting of the Houston Chapter of the API and the Gulf Coast Section of the Society of Petroleum Engineers of the AIME.

Halbouty differentiated between mandatory pooling, which he identified as being on an established unit basis, and fieldwide compulsory unitization. He said, however, that compulsory unitization, under federal law, was a strong possibility in this country unless steps were taken soon to correct present inequities in conservation laws and regulations.

He said he was convinced that compulsory unitization could solve a great number of problems under present conservation laws and that he was certain it would come in time. But, he added, it is those who are taking advantage of the weaknesses in petroleum conservation regulation today who will make it come sooner than expected.

"And it is they," he said, "not the operator who abides by the spirit as well as the letter of conservation law, who must bear the onus of bringing compulsory unitization about."

He said that if mandatory fieldwide unitization ever comes, and he said the evidence was that it would eventually become necessary, "then it must come from the state rather than from the federal government if we are to avoid federalization of this industry."

In an ever growing number of instances, Halbouty said, some of the 1930 conservation laws, when applied to modern gas fields, actually encourage rather than prevent waste of gas and liquids.

He attributed much of this to a misinterpretation of the Law of Capture, which provides that any producer is entitled to any production that comes out of his oil or gas well.

"However, this very simple rule has come to mean many things to many people. The most serious misunderstanding in its application is the assertion by town lot owners and segregated small tract operators that the rule means more than non-accountability. These people contend that it confers an affirmative absolute right of a well owner to drain oil and gas from his neighbor," Halbouty said.

"Article 6008 of the Texas statutes specifies that the gas allowable from a reservoir must be allocated among all wells so as to give each well its "fair share" of the gas to be produced from the reservoir.

"Now what does fair share mean?" Halbouty asked. "The courts have repeatedly said that fair share means the approximate amount of gas underlying a particular tract. Any allocation formula is confiscatory (and therefore unlawful) which does not allocate to all wells in a reservoir approximately the gas in place under the tracts upon which wells were located."

Halbouty also warned that unless Texas acts to modernize its conservation laws, rules and regulations, it will continue to lose investments in petroleum, its most important industry. But, Halbouty said, wider spacing is the answer only if arbitrary allocation formulas are modernized.

"The wider the spacing, the greater the confiscation and creation of waste by these small tracts," Halbouty said, "unless — and I repeat — unless the allocation formulas in use today are changed to meet the requirements of wider spacing. Those who advocate wider spacing must bear this (allocation) in mind or we will find ourselves in an even worse position than we are now," he said.

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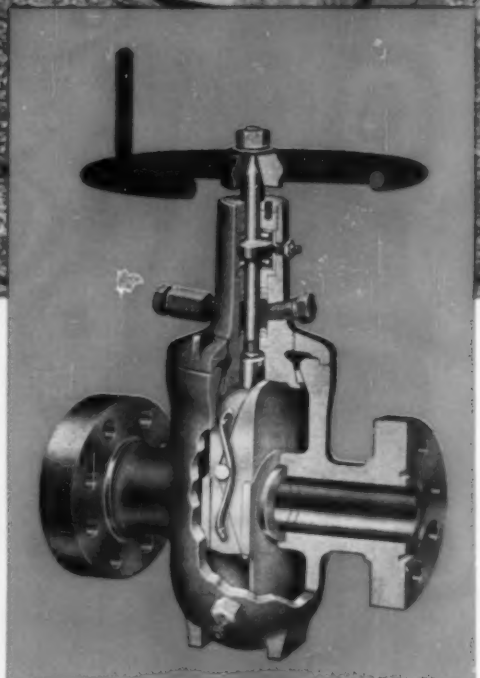

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5917-R

A mathematical study of . . .

Two-Phase Flow In Well-Flowlines

Bryan T. Yocum, *Arabian American Oil Company, Dhahran, Saudi Arabia*

***Part 2** completes a discussion of simultaneous flow of gas and oil in wells and flowlines and solves example problems with equations developed in Part 1*

Flowline Pressure Drop vs Flow Potential

The relationship results from solving Equations 13, 18, and 19 simultaneously. For design purposes it has been found both adequate and convenient to assume the average flowline temperature at 120 F. The flow capacities will then estimate low and a conservative design will result. The resulting equation is:

$$\frac{p_1^2 - p_2^2}{L} = \frac{3.8f(MW)^2(GOR)}{D^5} \quad \text{(D in inches)} \quad . \quad . \quad (27)$$

This equation is useful for getting quick estimates of flowline size for a given application, or, the flow capability of an existing line. Fig. 18 is a plot of Φ versus X where

$$\Phi = \frac{p_1^2 - p_2^2}{L} \quad . \quad . \quad . \quad . \quad . \quad (28)$$

and

$$X = \frac{(MW)^2(GOR)}{D^5} \quad . \quad . \quad . \quad . \quad (29)$$

Equation 27 is therefore reduced to

$$\Phi = 3.8f\,X \quad . \quad . \quad . \quad . \quad . \quad (30)$$

What is the flow capacity of a 12-in. flowline 36,000 ft long with an upstream pressure of 560 psi, downstream pressure of 50 psi and a GOR of 840 cu ft per bbl? Neglect elevation effects.

$$\Phi = \frac{(560)^2 - (50)^2}{36{,}000} = 0.80$$

As a first pass assume that the velocity is high enough to be in the Reynolds Number range. Assume an f of 0.025.

$$X = 8.5 = \frac{(MW)^2(840)}{(11.938)^5}$$

$$MW = \sqrt{\frac{(8.5)(242{,}470)}{840}} = 49.6 \text{ lb per sec}$$

Average mixture density:

$$\rho_m = \frac{(23)(305)}{840} = 8.4 \text{ lb per cu ft}$$

Linear velocity:

$$v = \frac{49.6}{(8.4)(.785)} = 7.55 \text{ ft per sec}$$

Froude Number squared:

$$N_F^2 = \frac{(7.55)^2(12)}{(32.2)(11.938)} = 1.78$$

N_F^2 is in the low velocity range. From Fig. 7[6] the friction factor is estimated at 0.037. The corresponding value of X is:

$$X = \frac{0.80}{(3.8)(.037)} = 5.54$$

Inspecting Fig. 18, if $\Phi = 0.80$ and $X = 5.54$, the friction factor f is 0.037. This checks with the above value.

The W value for this crude is 4.16×10^{-3}. The flow potential of the line is therefore

$$M = \frac{1}{4.16 \times 10^{-3}} \sqrt{\frac{(5.54)(242{,}470)}{840}} = 9600 \text{ bbl per day}$$

This is only a first pass estimate because the mean density is for the entire line. To improve the accuracy, divide the line into three sections, and calculate the pressure profile from the trap back to the well at 9600 bbl per day. The flow potential to match 560 psi wellhead pressure can then be estimated relative to the 9600 mean bbl per day profile. The improvement comes from better estimation of the mean densities along the line.

Well-Flowline Flow Potential Curves

Fig. 9 shows a graphical way of preparing flow potential vs flowing bottom-hole pressure for a well-flowline installation (Fig. 10). The flowline pressure drop vs flow potential curve, such as can be developed from Equation 27, are solved simultaneously with the wellhead pressure vs flow curves for the oil well (Fig. 6[6]).

Fig. 10 is a very practical curve for planning and budget work. Over 100 have been prepared covering a wide range

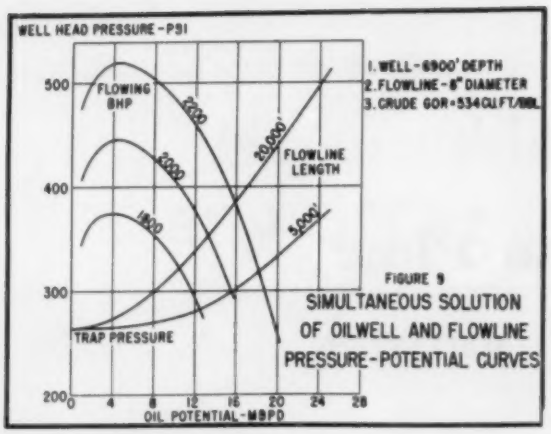
WELL HEAD PRESSURE - PSI
1. WELL - 6900' DEPTH
2. FLOWLINE - 8" DIAMETER
3. CRUDE GOR = 534 CU FT/BBL
FLOWING BHP
FLOWLINE LENGTH
TRAP PRESSURE
OIL POTENTIAL - MBPD

FIGURE 9
SIMULTANEOUS SOLUTION OF OILWELL AND FLOWLINE PRESSURE-POTENTIAL CURVES

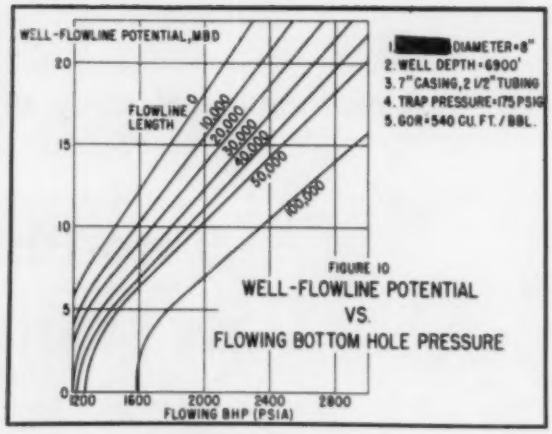
WELL-FLOWLINE POTENTIAL, MBD
1. [redacted] DIAMETER = 8"
2. WELL DEPTH = 6900'
3. 7" CASING, 2 1/2" TUBING
4. TRAP PRESSURE = 175 PSIG
5. GOR = 540 CU. FT. / BBL.
FLOWLINE LENGTH
FLOWING BHP (PSIA)

FIGURE 10
WELL-FLOWLINE POTENTIAL VS. FLOWING BOTTOM HOLE PRESSURE

of each major variable, 4 to 16-in. flowline diameters, 6 crude types, and flowline lengths varying from 0 to 100,000 ft.

Well-Flowline Flow Potential vs Reservoir Pressure

There is often considerable variation in the productivity index of an oilfield. Fig. 10 can be prepared independent of reservoir hydraulic characteristics. However, by crossplotting the productivity index as in Fig. 11, a simultaneous graphical solution resulting in Fig. 12, well-flowline flow potential vs reservoir pressure, is obtained. This curve is useful in estimating future production from the well flowline installation and future well-flowline requirements.

Although not shown in Fig. 11, Fig. 12 includes the decreasing productivity index found at reservoir pressures below the bubble point. These curves do not apply when gas oil ratios in excess of the solution GOR are entering the well bore.

Correction charts. The well depth and the trap pressure are usually held constant in preparing these charts. In order to increase the utility of Fig. 10 and 12, corrective charts, Fig. 13 and 14, have been prepared to correct the potential estimates for variations in well depth and trap pressure.

With Fig. 10, 12, 13, and 14 available for an oilfield, rapid estimating of flow potentials or flowline sizes is possible.

SAMPLE CALCULATIONS

These fairly complicated equations have to be solved simultaneously both in the oil well and the flowline. The hand calculations are laborious. It was found economic to program them on computers. However, a sample calculation will best illustrate the methods developed for solution of the equations.

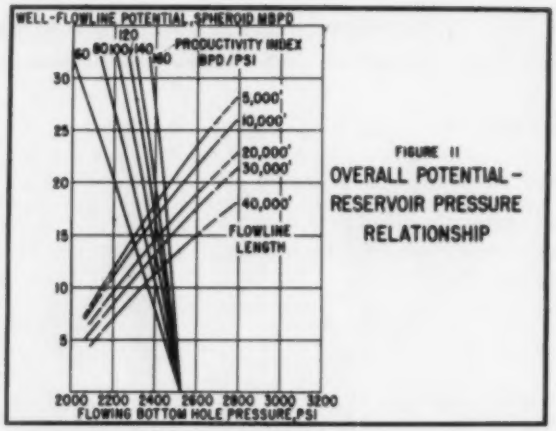

FIGURE 11
OVERALL POTENTIAL - RESERVOIR PRESSURE RELATIONSHIP

Oil Well

The first step is to reduce the complex annulus equation to a simple graphical form. This is done by defining a ψ factor.

$$\psi = \frac{144}{\rho\left[1 + \frac{8f(MW)^2}{\rho^2\pi^2 g_c (D_1 - d_o)(D_1^2 - d_o^2)^2}\right]} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (31)$$

which simplified Equation 3 to

$$\Delta Z = \psi \Delta p \quad . \quad . \quad . \quad . \quad . \quad . \quad (32)$$

The Author

Bryan T. Yocum *is presently engaged in economic studies and long range planning, as well as his primary specialty — applied fluid flow, for the Arabian American Oil Company in Dhahran, Saudi Arabia.*

He was graduated from Columbia College, receiving bachelor of arts degree in 1951, and from Columbia School of Engineering, receiving a bachelor of science degree in chemical engineering in 1952. He worked as junior development engineer, American Cyanamid Company, Bound Brook, New Jersey, from 1952 to 1954.

He joined Arabian American Oil Company in 1954 as study engineer in the New York office engineering department. In 1956, he transferred to Saudi Arabia as general office engineer, plants and pipelines. In 1957, he was engineering representative to Aramco's Future Oil Development Program. More recently, he served as acting supervisory engineer, general office engineering, plants and pipelines.

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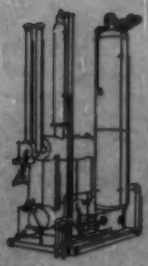

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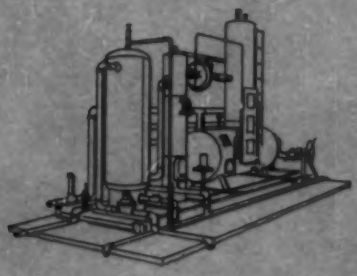

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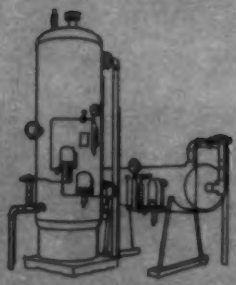

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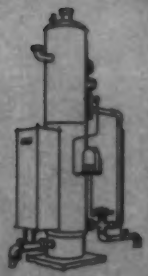

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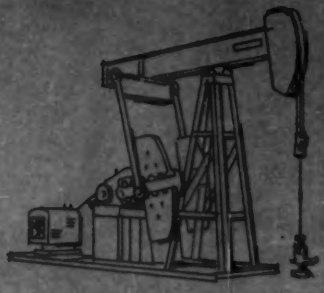

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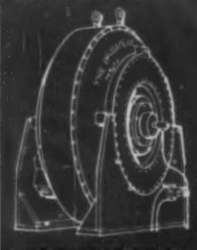
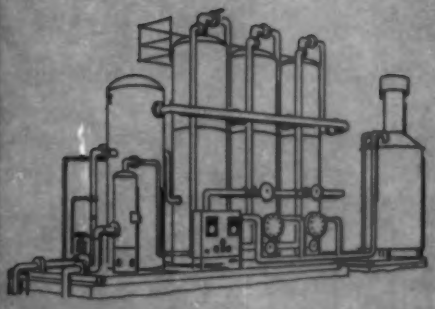
METAL BUILDINGS



HYDROMATIC BRAKES



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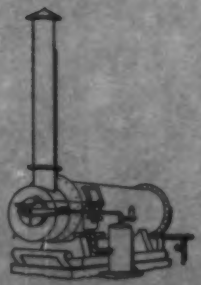

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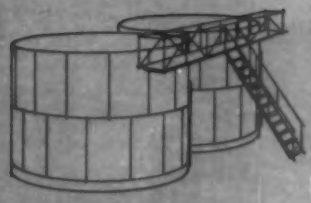

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A plot of ψ for standard 7-in. casing and 2½-in. tubing is given in Fig. 15 as a function of mixture density.

What is the wellhead pressure of a 7000 ft deep oil well flowing 9000 bbl per day if (1) reservoir pressure = 2800 psi, (2) productivity index of the formation = 27 bbl per day per psi, (3) reservoir temperature = 213 F, (4) 7-in. casing and 2½-in. tubing?

Experience has shown that 90 to 95 percent of the flow is up the annulus. Tubing flow is usually estimated as a percentage of annulus flow.

$$\text{Flowing bottom-hole pressure} = 2800 - \frac{9000}{27} = 2467 \text{ psi}$$

The PVT data of the reservoir fluid are expressed as a mixture density chart in Fig. 5[6]. The stock tank oil has an API gravity of 34.5, the GOR is 580 cu ft per bbl, and the total gas molecular weight is 33.

$$W = \frac{5.62(53.0) + 2.64 \times 10^{-3}(580)(33)}{86{,}400} = 4.03 \times 10^{-3}$$

Calculate Γ to get the temperature profile

$$\Gamma = \frac{(12)(3600)(4.03 \times 10^{-3})(9 \times 10^{-3})(0.57)}{(2.2)(6.875)} = 49{,}000$$

The reservoir temperature is 213 F so we can use Fig. 2[6] directly. Experience has shown that for different reservoir temperatures, Fig. 2[6] can be used by adding the difference between it and 213 F to the well temperature profile.

Inspection of Fig. 5[6] shows a bubble point pressure of around 1850 psi in the 200 to 210 F range.

First Step – Bottom-hole to bubble point.

$$\Delta p = 2467 - 1850 = 617 \text{ psi}$$
$$\rho(\text{at } 210 \text{ F}) = 44.2 \text{ lb per cu ft}$$
$$\psi = 3.12 \text{ (Fig. 15)}$$
$$\Delta Z = (3.12)\ (617) = 1920 \text{ ft}$$
$$t = 210 \text{ F (Fig. 2[6])}$$

Second Step. There is a rapid rate of change of mixture density with pressure immediately below the bubble point. At lower pressures the relationship straightens out to be nearly linear. When a computer is used, the density increments can be taken small, 5 or 10 percent, but in hand calculations we want the increment as large as possible. Take 10 percent in this region of rapid change.

$$\rho_m = 44.2 - \frac{(0.10)(44.2)}{2} = 42.1 \text{ lb per cu ft}$$

$$\rho_f(\text{end of step}) = 44.2 - (0.10)(44.2) = 40.0 \text{ lb/cu ft}$$

$$\psi_m = 3.26$$

Inspecting Fig. 5[6] we see that the pressure at 40 lb per cu ft and 210 F is 1580 psi. The elevation change would be:

$$\Delta Z = (3.26)\ (1850 - 1580) = 880 \text{ ft}, f_2 = 2800 \text{ ft}$$

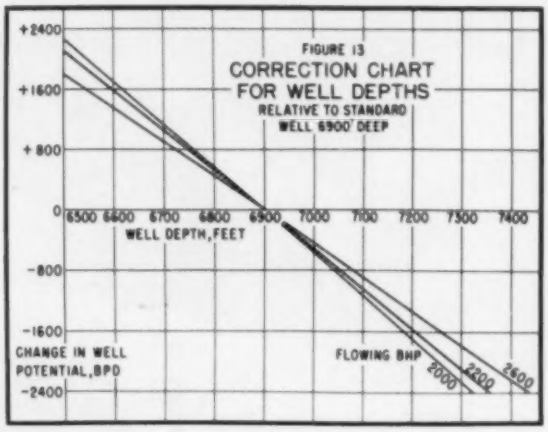
Inspecting Fig. 2[6], the temperature at 2800 ft is 208 F. Correct the pressure p_f to 208 F and 40 lb per cu ft, or 1570 psi. Correct elevation to:

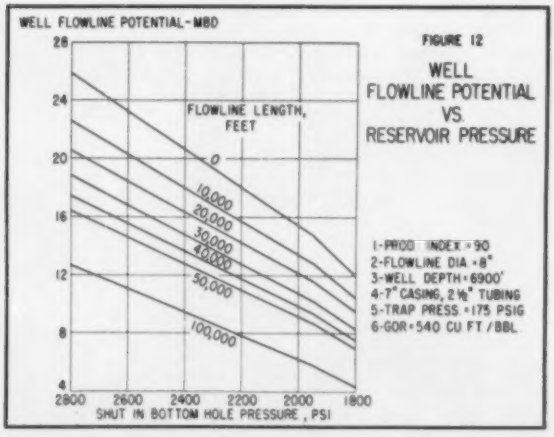
$$\Delta Z = (3.26)\ (1850 - 1570) = 913 \text{ ft}, f_2 = 2833 \text{ ft}$$

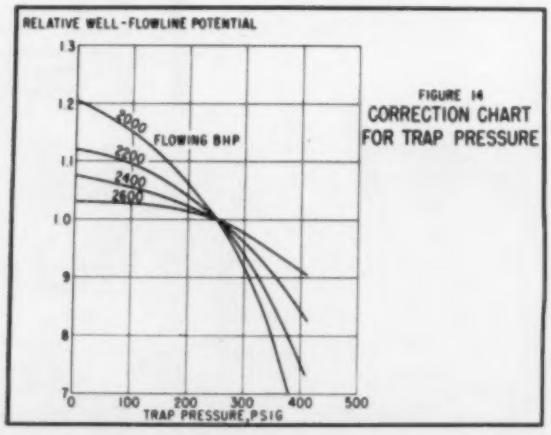
Continue on with 10 percent increments in density until in the linear range, then increase to 15 to 20 percent.

The wellhead pressure is 620 psi and the temperature is 184 F.

In the usual case, a range of flowrates are calculated for several reservoir pressures down to the bubble point. Plots like Fig. 6[6] giving wellhead pressure vs flow potential result.







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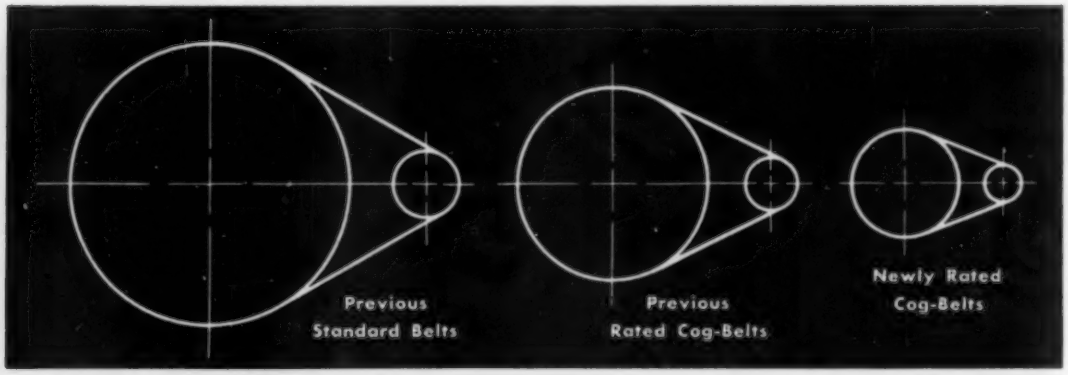

The Dayton Rubber Company proudly announces the findings of the most extensive, thorough analysis project in the V-Belt power transmission field, during which literally hundreds of thousands of V-Belt drives were evaluated by a renowned, independent engineering laboratory.

This long-term project was initiated because Dayton Cog-Belt performance had been noticeably upgraded over a period of years, through continued research and development in new materials and improved features . . . indicating that heretofore established HP ratings have become obsolete.

The result: Important new increases in Dayton Cog-Belt horsepower ratings . . . *now 2 to 3 times higher than previous standard V-Belt ratings.*

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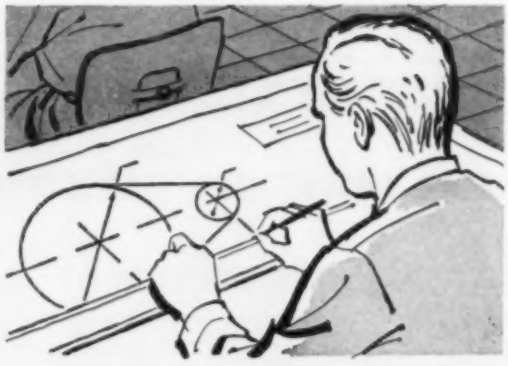
Dayton Cog-Belts, delivering 2 to 3 times more horsepower, permit drive designers to use narrower sheaves, less grooves, fewer belts for any V-Belt drive. *Two Cog-Belts do the work of 4 to 6 previous standard V-Belts.* Drive space thus saved permits new compactness of design, lighter weight and lower cost . . . job-proven on thousands of power drives throughout all industry. First costs and maintenance costs can be substantially reduced with Dayton Cog-Belt drives.



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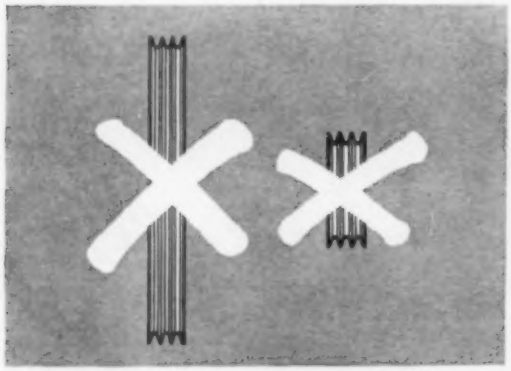
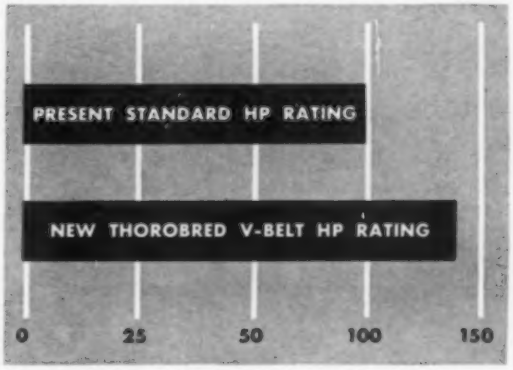
Horsepower Capacity previous Standard Belt Ratings

Drive Space, Weight . . . using *existing industry-standard sheaves.*



No special sheaves required . . . Existing sheave stocks usable.

Using long-accepted industry-standard sheaves, *Dayton Cog-Belts do not obsolete present stocks of sheaves* . . . drives can be assembled from any existing inventories. Newly-rated Dayton Cog-Belts permit use of sheaves with smaller diameters and comparably closer centers . . . always at a savings in cost and weight. Because Dayton Cog-Belts operate on industry-standard sheaves, there is no need to stock additional special sizes. Present inventory stocks allow you to cover a greater range of higher horsepower capacities.



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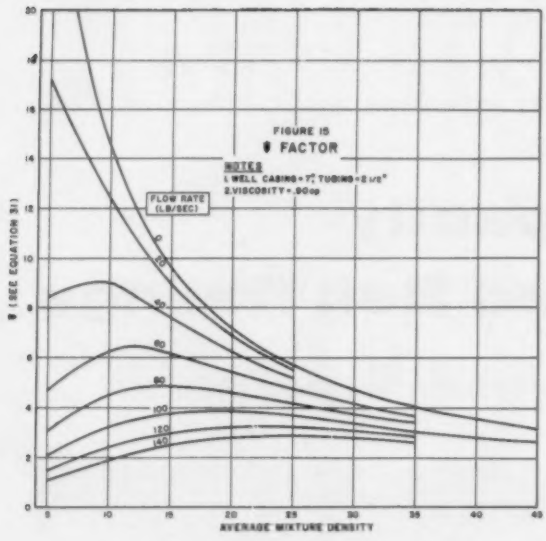


Flowline

In order to generalize the flowline calculation method, the influence of temperature and of elevation must be considered.

The influence of temperature on the K constant is

$$0.1093 - 1.17 \times 10^{-4}(t + 460) = \frac{K}{GOR} \quad . \quad (33)$$

If the GOR is known, K can be determined at any temperature. Therefore, the change in the constant in Equation 27 is known. Equation 27 is generalized to:

$$\frac{p_1^2 - p_2^2}{L} = \gamma f \frac{(MW)^2(GOR)}{D^5} \quad . \quad . \quad (27A)$$

Using the same crude as in the oil well case, calculate the pressure drop in a 6-in. flowline 25,000 ft long, considering elevation and temperature effects, flowing 9000 bbl per day.

The temperature profile will be based on a maximum ambient temperature of 110 F. This leads to conservative estimates of flow potential and pressure drop.

Calculate α:

$$\alpha = \frac{(3.26 \times 10^{-4})\ (6.065)^2\ L}{(3.74 \times 10^{-3} \times 9000)^{0.8}(12)^{0.2}} = 3.32 \times 10^{-5}\ L$$

Determine the temperature profile from Equation 18:

$$t_1 = (110 + 10) + \frac{184 - 110}{10^{3.32 \times 10^{-5} L}}$$

The results are tabulated:

L – ft	α	10^{α}	t_1 – F
0	0	1	194
5,000	0.166	1.47	173
10,000	0.322	2.10	155
15,000	0.500	3.16	143
20,000	0.665	4.62	136
25,000	0.830	6.75	131

For calculation purposes, we divide the flowline into three sections each 8330 ft long. The mean temperatures are:

1st section – 173 F
2nd section – 149 F
3rd section – 135 F

The K factor in Equation 33 and, more importantly, the γ factor in Equation 27A can now be calculated

$$\gamma = \frac{87.4}{K} \quad . \quad . \quad . \quad . \quad . \quad (34)$$

when the diameter units are inches and psi for pressure.

First Section

For first section, 173 F.

$$0.1093 - (1.17 \times 10^{-4})\ (173 + 460) = \frac{K}{580}$$

$K = 20.4$.

The results are tabulated:

Section	t_m	K	γ
1st	173	20.4	4.27
2nd	149	22.0	3.98
3rd	135	23.0	3.80

Examining the elevation profile of the line, we find

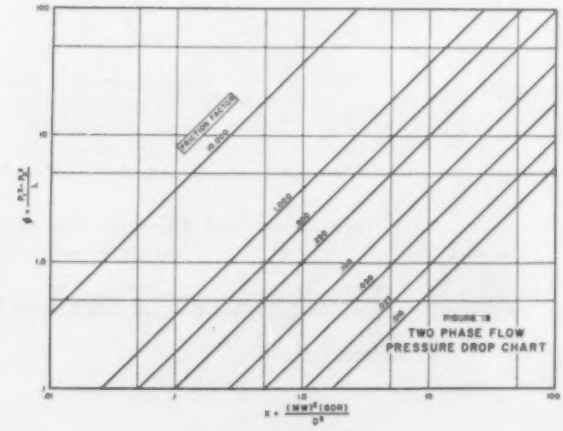
1st section	+ 123 ft
2nd section	0
3rd section	– 64 ft

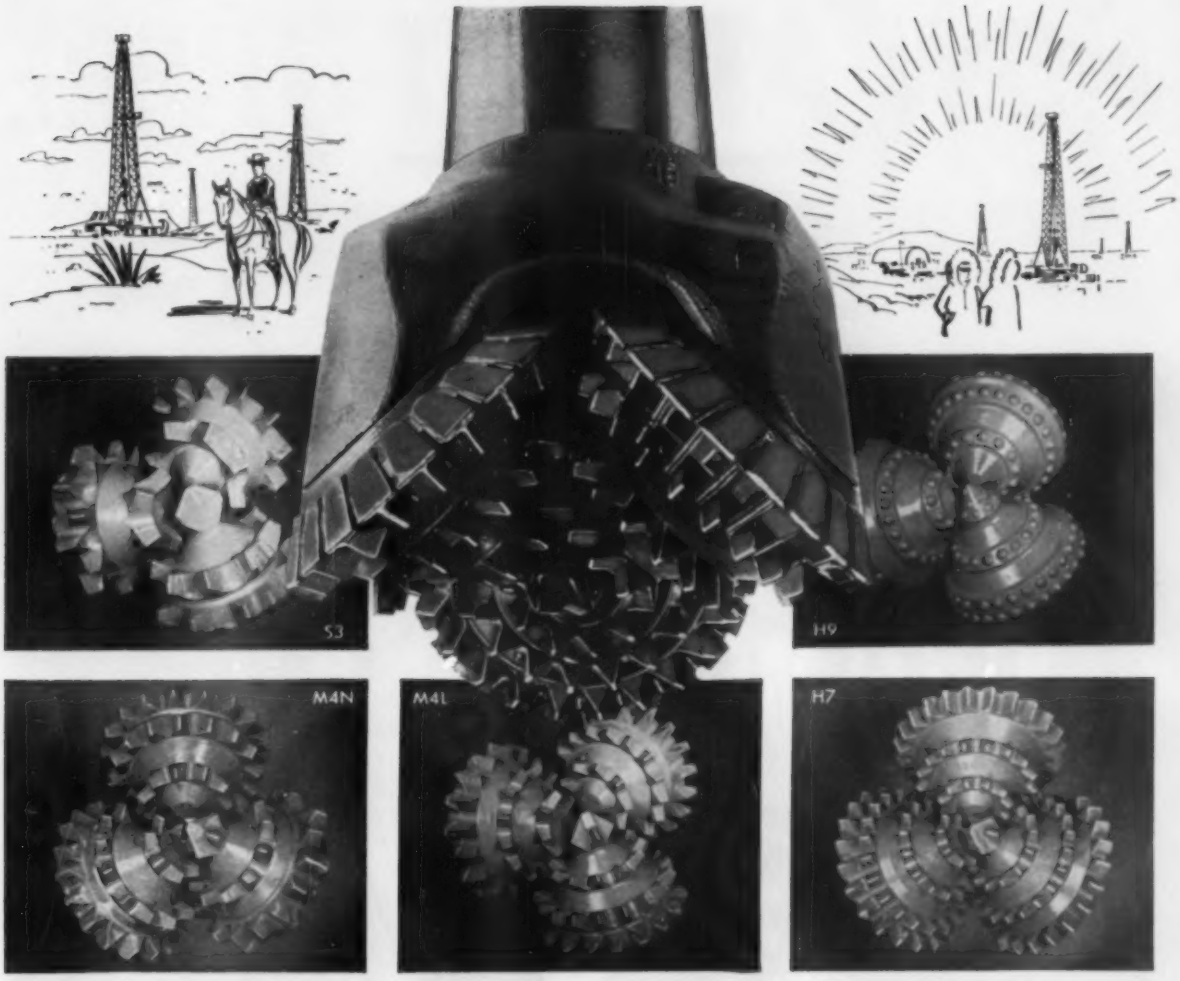
At 9000 bbl per day in a 6-in. line, we are probably in the high velocity range. From Fig. 16, we estimate f at 0.020.

Calculate X

$$X = \frac{(36.4)^2\ (580)}{8206} = 93.5$$

$\Phi = 7.1$ (Fig. 18)





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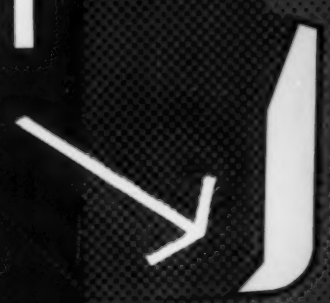

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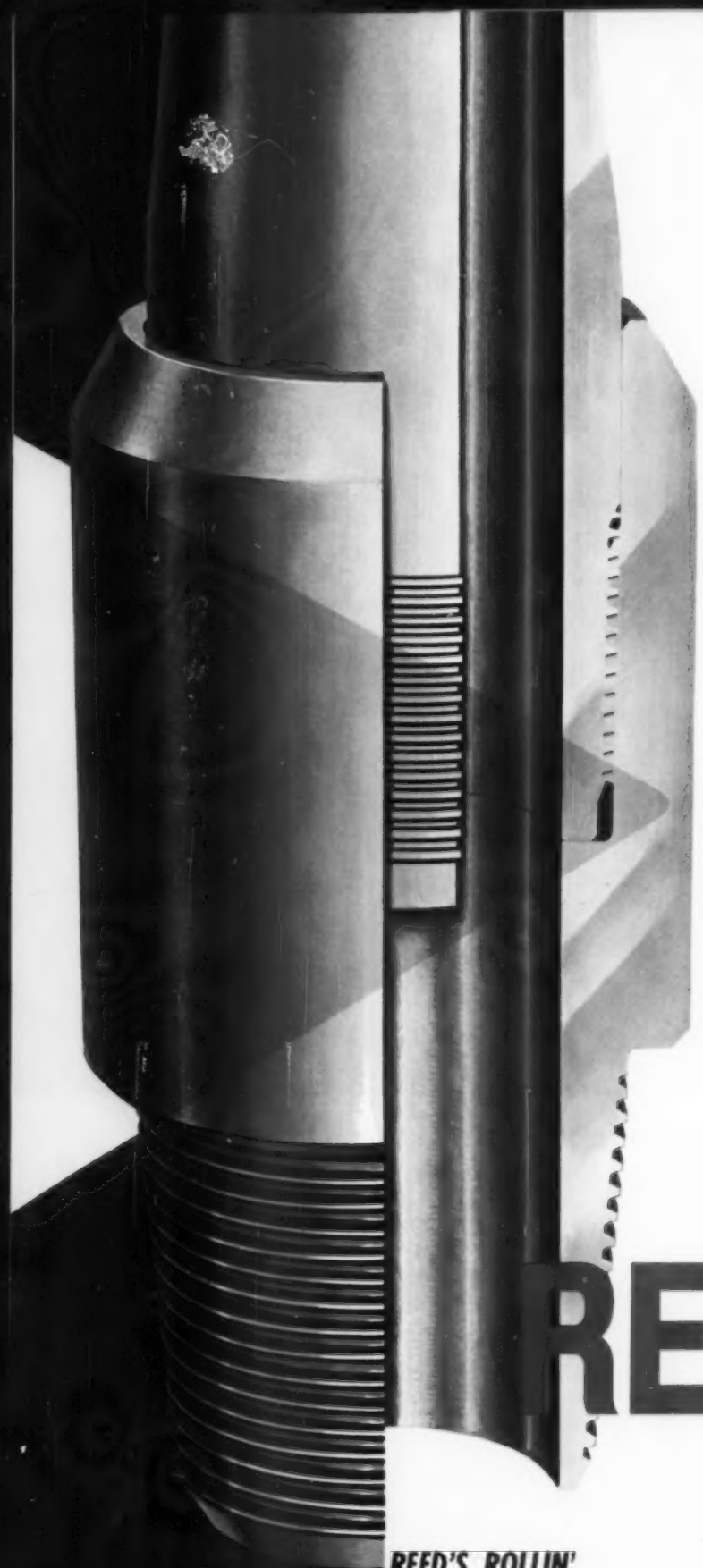

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- *the new Reed Relief Groove (increases fatigue life)*
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- *positive, correct make up at all seals*
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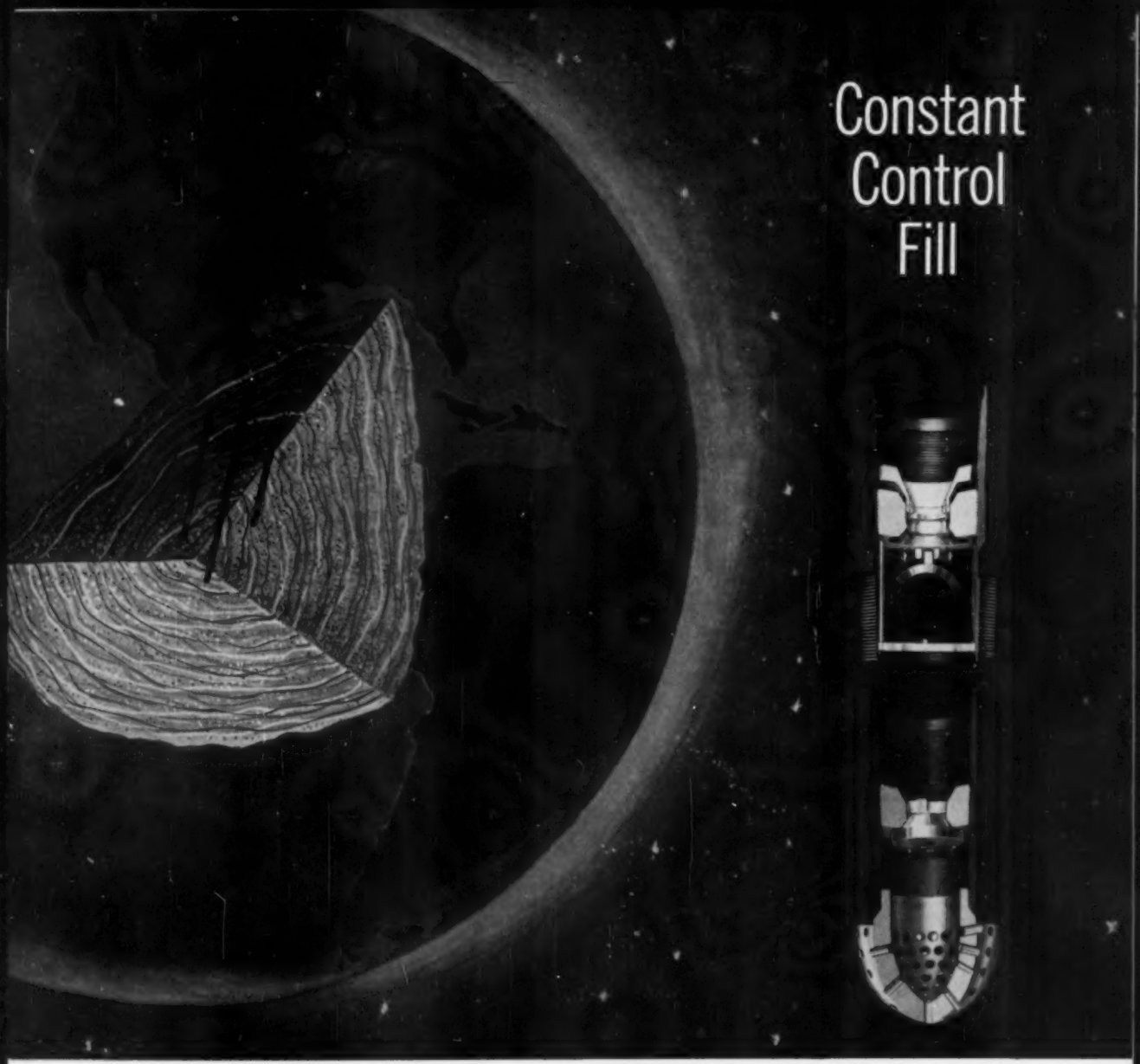

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Well	BEFORE TREATMENT		AFTER KONTOL SQUEEZE TREATMENT	
	Tubing Failures Per Year	Iron Loss (Lbs/Day)	Tubing Failures Per Year	Iron Loss (Lbs/Day)
A	2	3.8	0	0.7
B	2	4.5	0	0.7
C	4	8.8	2	4.3
D	1	10.1	0	0.6
E	1.7	11.2	0	1.6
F	2	8.8	0	0.5
G	1.3	4.7	0	1.0
H	1.5	3.3	0	0.5
	15.5	55.4	2	9.9

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TRETOLITE SERVICE
report

87% reduction saves $52,000 annually

Squeeze Application of KONTOL*CORROSION INHIBITOR REDUCES TUBING FAILURES FROM 15.5 to 2 PER YEAR

A corrosion control program employing KONTOL substantially paid off on a Texas lease. Based on the cost of pulling wells and replacing corroded tubing, an average of $4,000 per job, the savings in one year (based on figures in table above) approximated $52,000.

HOW KONTOL PROTECTION WAS ACHIEVED

KONTOL Corrosion Inhibitor was squeezed into the well formations at the rate of 55 gallons per well, followed by 2 quarts of TRET-O-LITE* demulsifying chemical in 15 barrels of oil, followed by oil injection sufficient to displace the liquid in the tubing and force the chemical into the formation. Injection was obtained by means of a 5 g.p.m. triplex pump and 40 g.p.m. centrifugal pump.

COST OF TREATMENT

The KONTOL squeeze treatment cost about 70 mills per barrel of produced oil and 1.9 mills per barrel of fluid produced. This resulted in a treating cost of 17 mills per barrel less than previous corrosion prevention methods.

This is just one of many cost savings stories on KONTOL Corrosion Inhibitor treatment. For more —and information on how to start a KONTOL Corrosion Control Program—ask the Man in the Red Car. Or write to . . .

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Wellhead pressure is 620 psi (oil well calculation):

$$p_2 = \sqrt{-(7.1)\ (8330) + (620)^2} = 570 \text{ psi}$$

The mean density in the first section (Fig. 5[6]) is:

$$\left.\begin{matrix} p_m = 595 \text{ psi} \\ t_m = 173 \text{ F} \end{matrix}\right\} \rho_m = 21 \text{ lb per cu ft}$$

The elevation head pressure requirement:

$$\Delta p_e = \frac{123}{144} \times 21 = +18 \text{ psi}$$

Pressure at the end of the first section is 552 psi. Check the friction factor.

Linear velocity is approximately:

$$v = \frac{(36.4)}{(20.8)\ (0.206)} = 8.5 \text{ ft per sec}$$

Froude Number $N_F{}^2 = \dfrac{(8.5)^2\ (12)}{(32.2)\ (6.065)} = 44.5$

From Fig. 16,[6] the friction factor is 0.0196.

Second Section

The Φ factor is 7.0 with f = 0.0196:

$$p_3 = \sqrt{(552)^2 - (7.0)\ (8330)} = 496 \text{ psi}$$

Third Section

$$p_4 = \sqrt{(496)^2 - (7.0)\ (8330)} = 434 \text{ psi}$$

Elevation Head

$$\left.\begin{matrix} p_m = 465 \text{ psi} \\ t_m = 135 \text{ F} \end{matrix}\right\} \rho_m = 18.2 \text{ lb per cu ft}$$

$$\Delta p_e = \frac{+64}{144} \times 18.2 = +8 \text{ psi}$$

Final pressure at end of flowline = 442 psi

Acknowledgments

Mr. M. Ludwig, engineering department, Standard Oil of California, first suggested using the Froude Number in correlating the flowline friction factor.

Messrs. W. M. Compton and F. Caponegro of Arabian American Oil Company both contributed to this program.

List of Symbols

Z = well depth, ft
p = pressure, psi
ρ = mixture density, lb per cu ft
v = velocity, ft per sec
g = acceleration of gravity = 32.2 ft per sec^2
$g_c = \dfrac{32.2 \text{ lb(mass)} \times \text{ft}}{\text{lb(force)} \times \text{sec}^2}$
dW_o = shaft work, ft
dW_f = friction loss, ft
M = oil flow rate, bbl per day
W = conversion factor, lb/sec/bbl per day
f = friction factor
f_{N_R} = friction factor from Reynolds Number
π = pi = 3.1416 . . .
D_i = inside casing diameter, ft
d_o = outside casing diameter, ft
D = diameter, ft
dQ = heat loss, Btu
t = temperature, F
U_w = oil well heat transfer coefficient, Btu/(hr) (ft^2) (F)
t_g = ground temperature, F
t_R = reservoir temperature, F
k = ground temperature gradient, F per ft
k' = flashing temperature drop constant, F per ft
Z_{BP} = bubble point length in oil well, ft
Γ = oil well temperature parameter
e = naperian log base = 2.718 . . .
V = volume, cu ft
GOR = gas-oil ratio, cu ft per bbl
m_g = molecular weight of gas
ΔH = elevation changes in flowline, ft
U_f = heat transfer coefficient in flowline, Btu/(hr) (ft^2) (F)
t_a = ambient temperature, F
t_o = initial temperature, F
L = flowline length, ft
h_i = inside film coefficient, Btu/(hr) (ft^2) (F)
h_o = outside film coefficient, Btu/(hr) (ft^2) (F)
h_s = steel heat transfer resistance, Btu/(hr) (ft^2) (F)
G = mass flow rate, lb/(ft^2) (sec)
C_p = specific heat, Btu/(lb) (F)
K = constant in ρ-p-GOR equation, lb/(psi)(bbl)
K' = constant in two-phase friction factor equation
A = constant, ρ-p-t relationship
B = constant, ρ-p-t relationship
N_F = Froude Number
N_E = Euhler Number
N_R = Reynolds Number
N_W = Weber Number
μ = viscosity, centipoise
T = interfacial tension, lb/(ft) (sec)
α = cooling constant, flowline temperature
γ = flowline coefficient
ψ = oil well coefficient, psi per ft
θ = thermal conductivity
ff = function sign

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In scaled-down wells . . .

Mechanical Aspects of Tubingless Completions

Use of small-diameter pipe as casing often eliminates need for inner string of tubing in well completions . . . results in efficiency and economy

Martin E. True
C. B. Corley, Jr.
Humble Oil & Refining Company
Houston, Texas

THE BROAD CHALLENGE of reducing costs of development and operation is now forcefully evident.[1,2] Although technological improvements and developments of leases and wells have made significant contributions toward offsetting the higher costs of operation and reduced income resulting from lower rates of production in prorated states, the economic problems faced by the domestic petroleum industry prompts a more diligent search for new ways to reduce costs and demands consideration of revolutionary innovations.[3]

One of the most significant tools for cost reduction in oil and gas well completions in recent years is the use of small-diameter pipe as casing.[4] In most cases, nominal 2½ in. tubing has been set as casing, and because no inner string of tubing is necessary for production in many wells, the terminology tubingless completion has resulted.

The tubingless completion is essentially the conventional oil or gas well in miniature. Basically, equipment and procedures that have been used for many years in conventional wells have been scaled down for tubingless completions.

Although this method of completing wells was used as early as 1942, more recent developments associated with permanent well completion techniques have increased the utilization of small-diameter casing. Currently, techniques and equipment for well and reservoir control and for completion and workover through small pipe are not only field-proved but also offer significant economic advantage.

The long experience in utilizing tubing as the production string in conventional single and dual wells and the more recent experience with tubingless completions themselves have established that the smaller, realistic size completions are adequate for the producing rates in most domestic wells.

Even though efficiency and economy can be obtained with present equipment, it is important that development work continue to obtain equipment and techniques specifically designed for small-diameter wells.

Single Tubingless Completions

The single tubingless completion is essentially a scaled-down version of a conventional size well, except that the inside tubing string may be eliminated for production in many wells (Fig. 1).

Equipment used in this type completion is the same as for larger wells, including a float collar, guide shoe, and other casing cementing equipment. To facilitate well control and workover with wireline tools, landing nipples used widely in the tubing of conventional wells may be installed in the casing string at predetermined depths.

Formation evaluation tools are available for the smaller hole sizes, and the commonly used through-tubing radioactivity and casing collar logs are available for use in 1½ in. or larger tubing. Steel-cased perforators have been developed which have good penetration and hole-size characteristics, and they leave no debris in the casing after firing. Wireline tools may be used in conjunction with a surface lubricator to provide supplementary well control, or a small tubing string may be installed to provide a circulating path if desired.

Experience of one operator includes 92 single tubingless completions in Texas, Louisiana, Mississippi, and New Mexico. Depths of these wells range from 1400 ft to greater than 10,000 ft, and average savings effected on wells for which cost data are available represent 19 percent of conventional well costs.

The majority of reduction in cost resulted from utilizing less steel for completion, but the savings also reflect improvements in other well completion practices which could have been applied to conventional wells. Savings of the same magnitude have been reported by other operators.[5]

Although single tubingless completions offer attractive monetary savings and provide safe and efficient well completion, control, and operation, further development is required to fully exploit this completion procedure.

A more efficient bit or cutting mechanism is needed that will drill holes as small as 4¾ in. at a rate commensurate with the reduced excavation required. Promising results have already been reported on one type drilling bit that should present no problem in scaling down.[6] Development of a satisfactory small-diameter bit would provide additional incentive for the development of small, highly portable drilling rigs and associated equipment with emphasis on automatic operation.

Casing generally used at present in tubingless completions is conventional 2⅞ in. OD tubing, and ¾ to 1½ in. tubing is used where needed for well control or artificial lift.

All of this pipe is currently premium priced relative to the quantity of steel involved.

Immediate attention for improvement should be given a number of associated small but important items of equipment – such as larger bore float collars and guide shoes which retain means for blowout protection, wiper plugs that insure effective displacement of cement on primary casing cementing operations, and a host of specialty tools

Presented by the author at the Petroleum Mechanical Engineering Conference, Houston, Texas, September 20-23, 1959, held by the American Society of Mechanical Engineers.

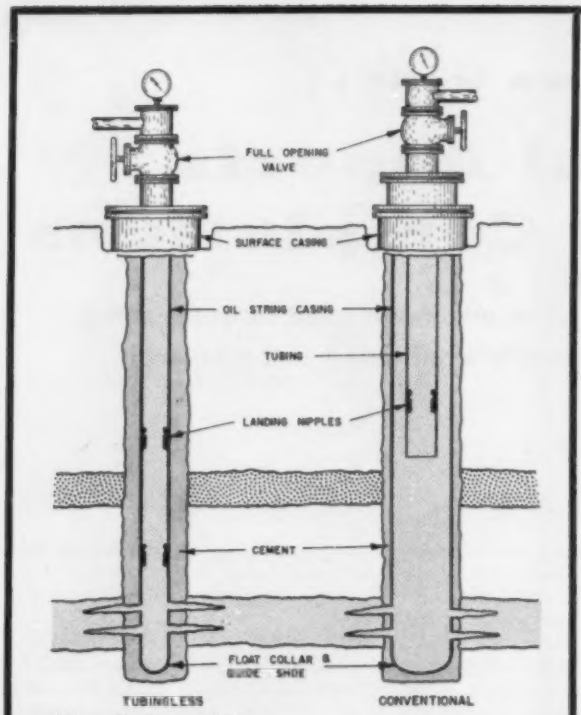

FIG. 1. Single completion.

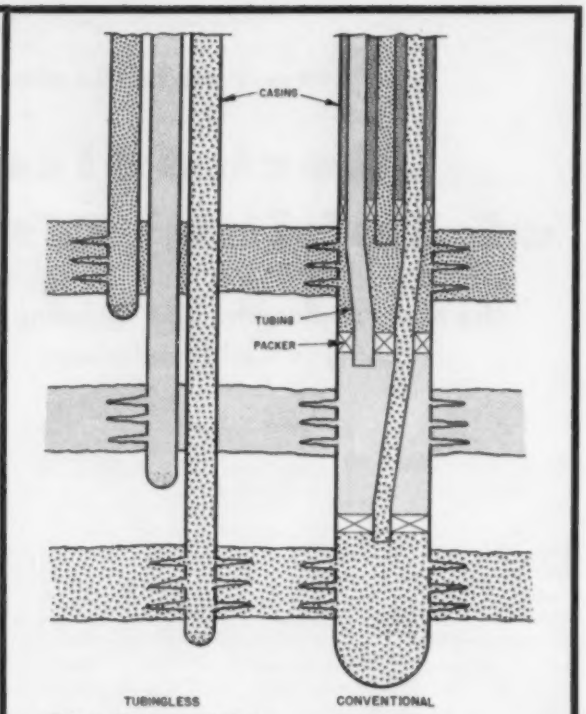

FIG. 2. Triple completion.

that provide increased efficiency and safety of operation inside the small casing and tubing.

Specialty tools needed include — wireline jet or chemical cutters and tubing perforators, wash pipe, mills, and fishing tools for efficient recovery of ¾ to 1½ in. tubing from 2⅞ in. OD casing.

The plastic patch[7] should be developed for 2½ in. casing with minimum restriction of the casing bore to permit continued use of all currently available pump holddowns and wireline tools.

Corrosion inhibitors with sufficient density to fall to bottom without excessive shut-in periods would eliminate the necessity of installing small tubing strings to conduct the chemicals to bottom.

Multiple Tubingless Completions

A number of dual and triple completions have been made by cementing conventional tubing as casing side by side in the same bore hole. This type completion provides significant versatility in completion and workover operations in addition to important savings (Fig. 2).

Early multiple tubingless completions were made by running clamped strings of casing with prepositioned orienting mandrels in the upper casing strings for directionally perforating.[8] A mechanical orienting device, commercially available, utilizes a spring-loaded arm attached to the directional perforator to orient with the maximum eccentricity of the mandrel and direct the charges in the proper direction (Fig. 3).

More recently, a directional perforating technique has become available which does not require preplaced mechanical devices in the casing for oriented perforating and has permitted casing strings of multiple completions to be run independently (Fig. 4).[9]

This method utilizes a focused radioactive source which is rigidly attached to a directional gun. The source and gun are rotated with a mechanical device operated by reciprocation of the wireline with 30 deg of rotation obtained with each vertical pull.

The orientation of the radioactive source, which is fixed in relation to the directional charges, is determined at the surface by a signal from a gamma ray detector run on a wireline in the adjacent string. The detector records a large peak on the sequence log as the focused source passes the detector.

This device may be utilized to perforate dual wells as described, and triple tubingless completions may be perforated by either (1) locating the relative positions of the three casing strings by obtaining recordings from the gamma ray detector run successively in the two strings adjacent to the casing containing the gun and radioactive source or (2) utilizing two gamma ray detectors installed in two strings simultaneously with the radioactive source and directional gun positioned in the third casing.

Developments required to fully exploit the multiple tubingless completion include those described for single tubingless completions, except that conventional size holes will be required when two or more small casing strings are set in the same well bore. In addition, development of versatile, low-cost wellhead equipment, especially for low-pressure service, is needed to permit quickly changing from either single or multiple casing hanger systems as well conditions warrant.

Current designs of wellhead and casing hanger arrangements for multiple tubingless completions do not facilitate low manufacturing costs or sufficient versatility in converting to a system for fewer casing strings on final completion than anticipated when drilling was initiated. Experience thus far indicates that strong consideration should be given to entirely new designs in wellhead equipment for this application. Even in currently available equipment, little standardization has been effected and costs are increased by the special design and order system imposed.

Although primary cementing of multiple tubingless completions has been accomplished with available equipment, the need is recognized for im-

proved scratcher and centralizer systems for casing strings run independently. Additional cost reduction could also be effected on these types of wells by development of perforator orienting equipment which eliminates the need for employing multiple conductor lines.

Artificial Lift

As in the case of completion equipment and procedures, artificial-lift methods used on conventional completions have been adapted for tubingless completions. All commonly used artificial-lift methods on tubingless completions may be utilized to accommodate a wide range of producing capacities and well conditions.

In sucker rod pumping, three subsurface installation arrangements are available (Fig. 5). Wells have been equipped with either 1¼ or 1½ in. tubing and commercially available conventional rod pumps with ½ in. sucker rods.

Hollow sucker rod installations have also been employed with fluid being produced through the hollow rods and the isolated annulus filled with inhibited oil to minimize casing wear and corrosion. For pumping wells which require a vent for gas production, hollow rods have been utilized with fluid being pumped up the annulus and gas produced through the hollow rod.

Full-size pumps on conventional rods have been employed to obtain increased lift capacity in wells which produce large volumes of water.

Other artificial-lift systems which may also be employed are hydraulic subsurface pumps and gas lift (Fig. 6).

Hydraulic subsurface pumps may be installed on small tubing to lift relatively large volumes of fluid while providing a flow path for corrosion and paraffin inhibitors. Gas-lift installations can be made with small gas-lift valves on 1¼ in. tubing run inside the 2⅞ in. OD casing.

Any of the artificial-lift methods described may be used for either single or multiple tubingless completions. One triple tubingless completion was equipped with rod pumps, and three pumping units were set head to head for production from the three wells. This serves amply to emphasize the need for development of equipment and techniques to provide artificial lift of multiple tubingless completions without requiring a multiplicity of surface installations.

The incentive and demand exist also for revolutionary new methods of artificial lift, such as:

1. A hydraulic, subsurface pumping system which is not critical as to the paraffin or solids content and the lubricating characteristics of the power fluid.

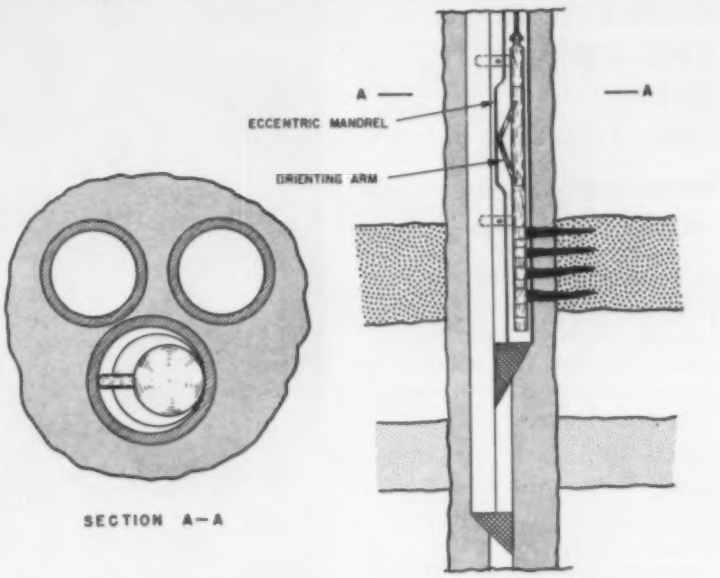

FIG. 3. Mechanical orienting perforator.

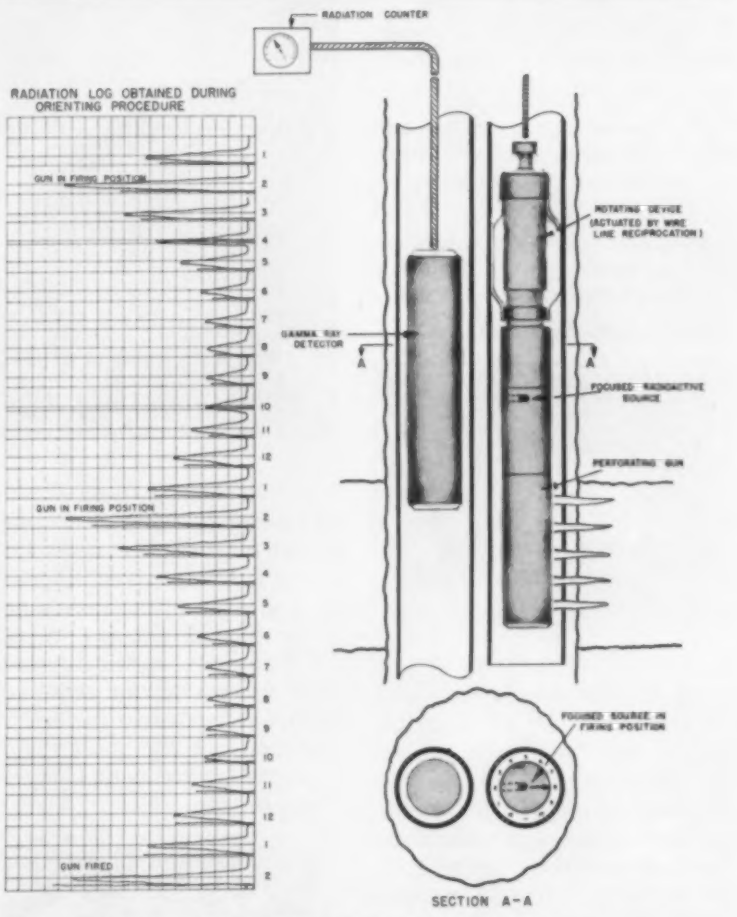

FIG. 4. Directional perforating technique utilizing radiation detector.

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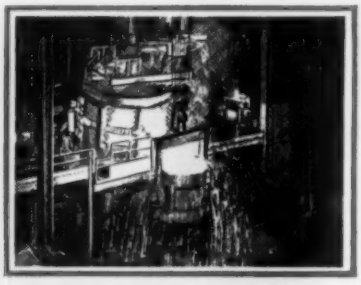

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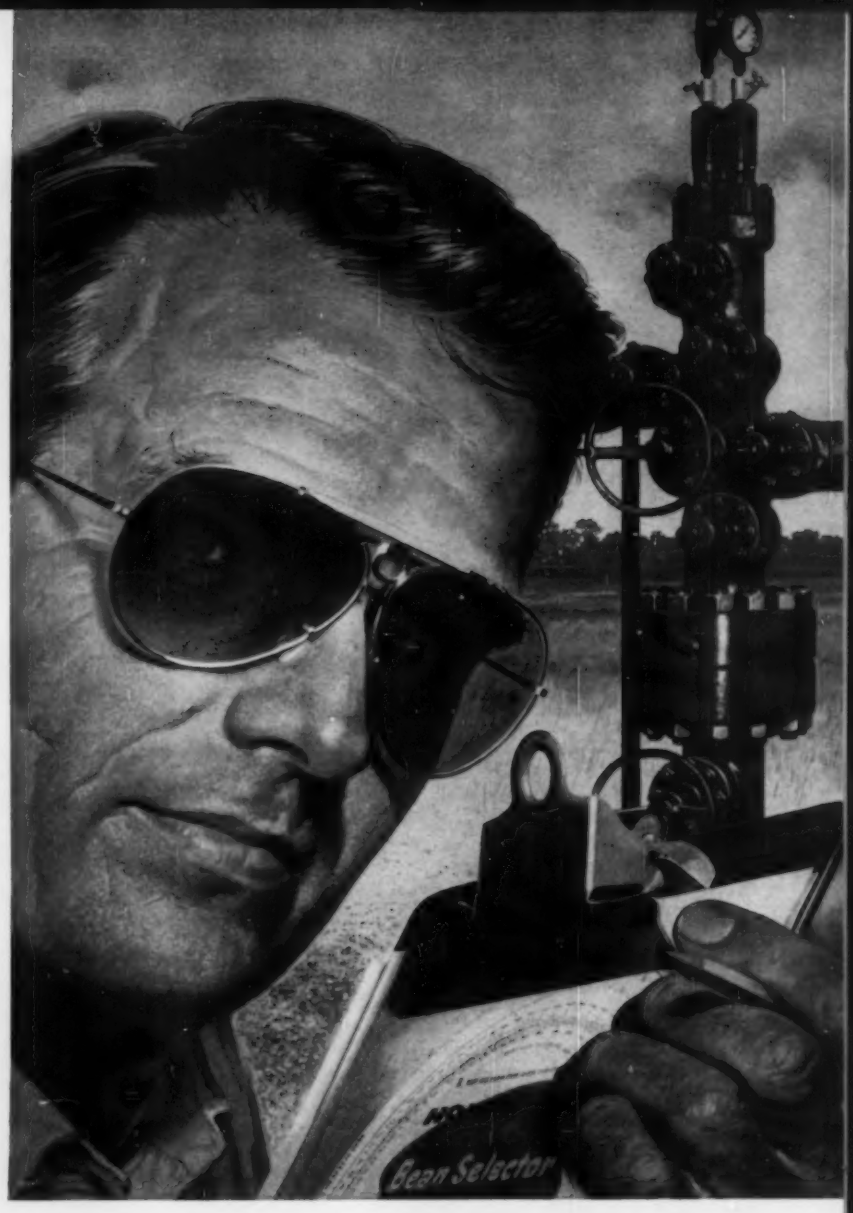

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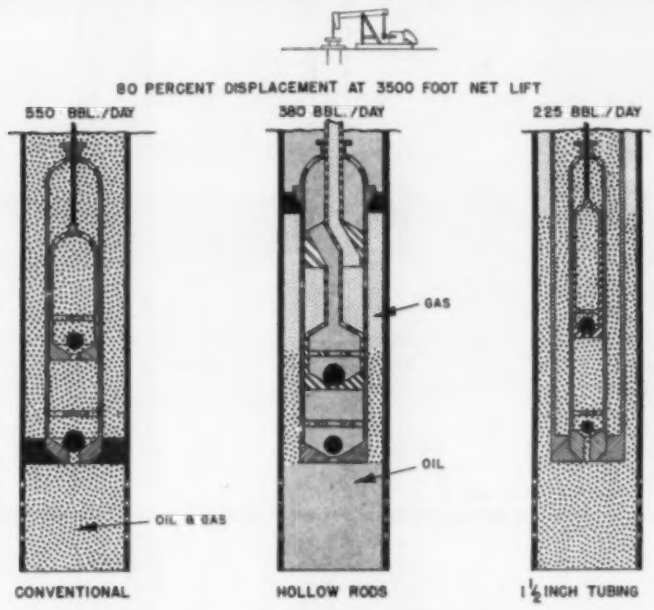

FIG. 5. Sucker rod pumping methods on 2⅞ in. casing completions.

2. A small-volume, electrically driven, subsurface pump and conductor system which would minimize downtime for servicing and eliminate the necessity of auxiliary tubing strings.

Workovers

Equipment and techniques are available to perform all types of workovers in tubingless completions. The permanent-type completion and workover techniques which were developed for conventional wells are applicable and are largely responsible for the increasing interest and utilization of the tubingless completion method. These techniques are not only field-proved for completion and workover operations but also offer significant economic savings relative to conventional workover methods.

Cement plugbacks may be performed economically with through-tubing dump bailers and bridge plugs (Fig. 7). One type of commercially available bridge plug is designed to support a 10,000 psi pressure differential and is made of aluminum to permit removal by either chemicals or drilling.

Landing nipples placed in the casing string at depths predetermined from logs may be utilized to permit installing a wireline retrievable plug for plugback (Fig. 8a) or recompleting lower by setting a packoff sleeve across existing perforations (Fig. 8b). A packoff sleeve utilizing slip-type anchoring devices may also be utilized to seal casing leaks (Fig. 8c). These devices are designed to permit retrieving by wireline should it become desirable to re-enter intervals for testing.

With ¾ in., 1 in., or 1¼ in. tubing as the conductor string, a small pulling unit can be utilized in conjunction with low-pressure squeeze-cementing techniques to perform economical workovers of tubingless completions (Fig. 9).[10] Small tubing can also be used to wash sand and to treat with plastic for sand control. Low-pressure squeeze-cementing utilizing macaroni tubing and consolidating plastics for sand control have been utilized with a high degree of success in both conventional and tubingless wells. Casing leaks resulting from rod wear, corrosion, or other reasons may be repaired by squeeze-cementing in the conventional manner.

Stimulation of productive formations

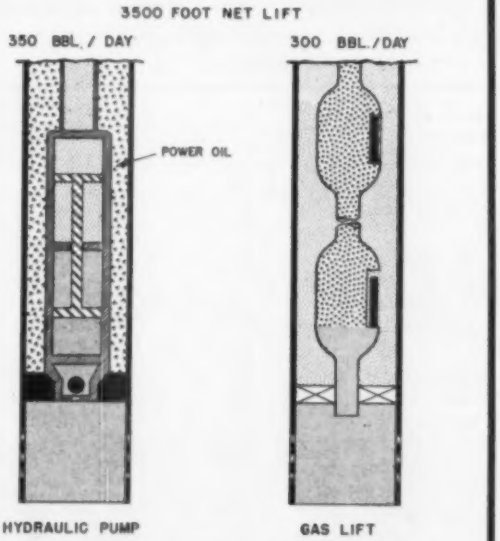

FIG. 6. Rodless pumping methods on 2⅞ in. casing completions.

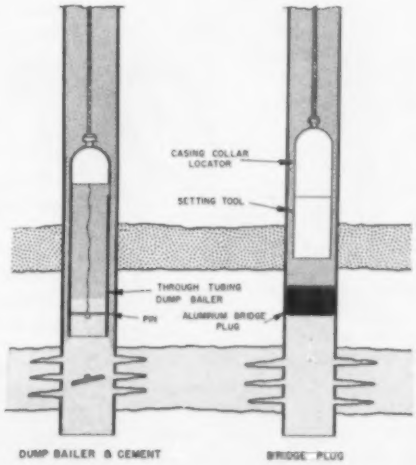

FIG. 7. Wireline plugback.

can be performed in tubingless completions with success comparable to that obtained in conventional completions. Fracturing at rates of approximately 10 bbl per min has been successful in tubingless completions and conventional wells in the West Texas and Southwest Texas areas when using fracturing fluids with properties designed to more efficiently utilize the energy available at the formation during injection.[11] Additives are commercially available to provide the desired properties in customary fracturing fluids.

All the techniques described for workover may be employed on either single or multiple tubingless completions if an orienting device is used for upper zone perforating in the multiple wells. In multiple completion work, workover and servicing operations can be performed without disturbing production from the adjacent completion.

Although small pulling units and associated equipment are available to permit efficient and economical servicing and reworking operations on tubingless completions, the incentive and need exist for equipment especially designed for this application with emphasis on increased automation.

Highly portable, compact units which contain hoists; masts; low-volume, high-pressure pumps; and all other necessary equipment would provide increased efficiency and lower cost of operation. With properly designed equipment, development of a new cementing material which would provide sufficient strength with only 2 to 3 hours waiting time would complete the package of workover procedures and provide a one-day operation for all types of tubingless completion workovers.

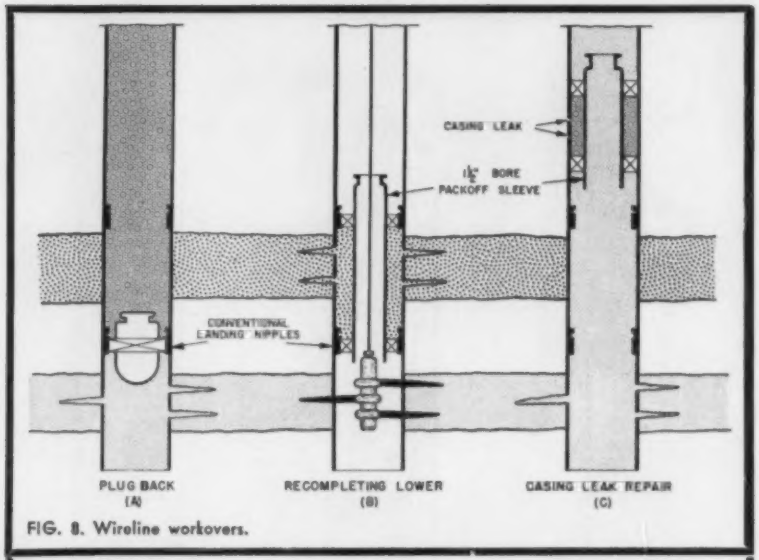

FIG. 8. Wireline workovers.

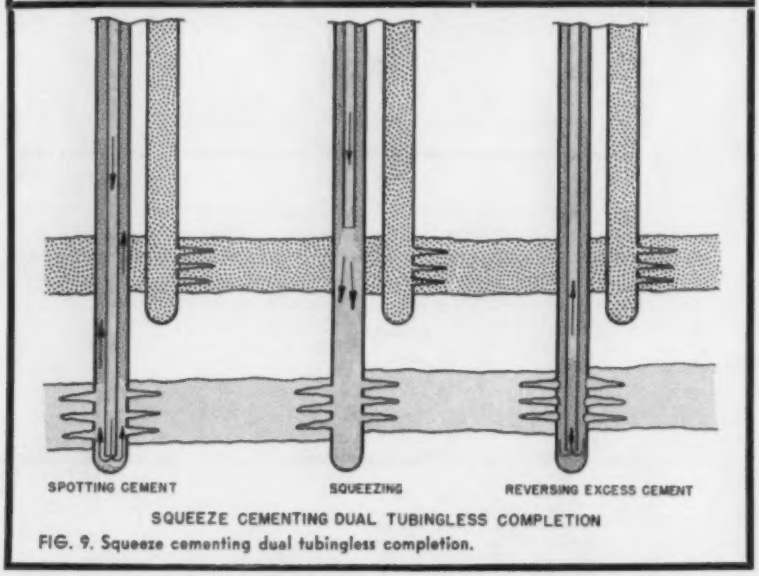

FIG. 9. Squeeze cementing dual tubingless completion.

Observations

For single and multiple wells made with conventional tubing as casing, equipment and techniques are available to permit efficient well completion and operation and to provide attractive savings. However, to fully exploit the tubingless completion method, effort should be directed toward accelerated development of equipment and procedures especially designed for small-diameter wells.

1. Tremendous incentive exists to develop small-hole drilling equipment and techniques with costs consistent with drilled hole size.
2. Significant additional cost reductions in completion and operation of tubingless wells would result with development of tubular materials with costs commensurate with steel involved and which provide increased resistance to wear, corrosion, and paraffin deposition.
3. A versatile system of low-cost wellhead equipment is needed for multiple tubingless completions.
4. Improvements of artificial-lift techniques, especially for multiple tubingless completions, should receive additional development effort.
5. Appreciable additional cost reductions and facility of operation would be effected through diligent development of the host of less significant but important specialty tools specifically designed for tubingless completions.

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8. "Here: Tubingless Triple Completions," *Petroleum Week* (November 21, 1958) 7, No. 21, p. 17.
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11. Willingham, J. E.: "Tubingless Completions in the West Texas Area," paper No. 906-4-C, API Southwestern District Spring Meeting, Midland, Texas, March 4-6, 1959. ★ ★

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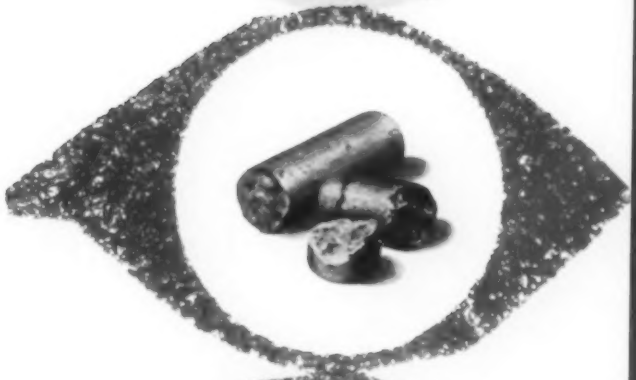

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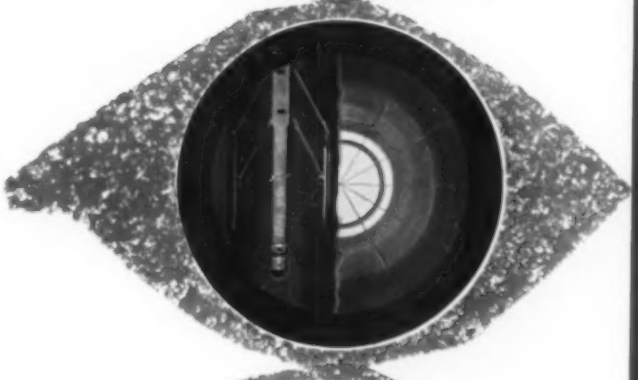

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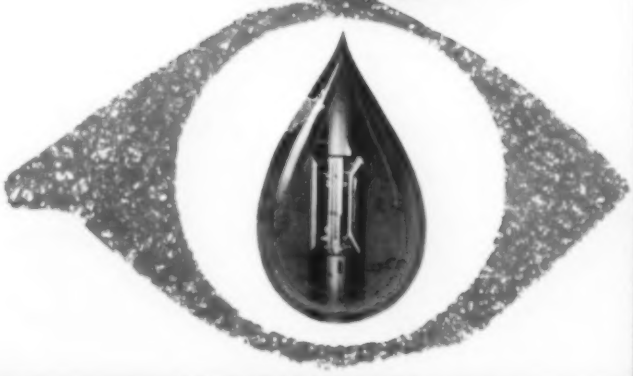

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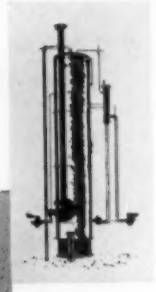

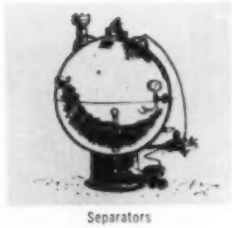

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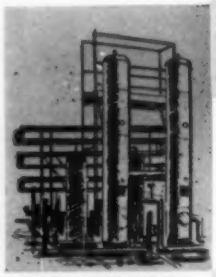

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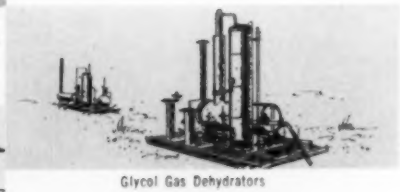

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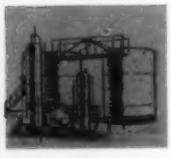

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Stekoll Steps Up Panhandle Activity

STEPPED UP ACTIVITY in Stekoll Petroleum Corporation's continuing development program in the Texas and Oklahoma Panhandles has been outlined by Marion H. Stekoll, president.

Since June, Stekoll has drilled 32 wells at an average cost of $90,000 each, and has acquired some 51,000 acres of land in an area lying along the west flank of the Anadarko Basin, the prolific oil and gas productive geologic feature which extends across Oklahoma into the Texas Panhandle.

Nine of the 32 wells are or will be completed as dual producers. Fifteen are successful oil wells, six are gas, three were dry, and 17 are in various stages of completion. Ten wells are presently being drilled.

Plans called for drilling 12 additional wells before the end of 1959.

Stekoll's initial entry into this area came last May when it purchased certain properties in Hansford and Ochiltree Counties, Texas, from Horizon Oil and Gas Company of Dallas. These properties included 11 producing oil wells, three producing gas wells, and more than 20 proven locations.

"We've only begun to scratch the surface in this area," Mr. Stekoll said. "Our production is primarily from formations of Pennsylvania Age in which there are a total of 14 producing zones, any of which may be considered the primary objective at a given location."

Stekoll's 32 wells have been drilled to depths ranging from 6000 to 11,000 ft and have been completed at an average cost of $90,000 each. This cost, which is about 25 percent below that of similar wells in the area, is made possible by the company's slim-hole completion techniques.

Since many holes penetrate multiple pays, the completion of wells as dual producers gives Stekoll a substantial increase in revenue with only slightly increased capital investment per well.

"This multiple completion potential combined with our low drilling costs and a high ratio of successful wells, makes this an excellent area in which to concentrate our expansion," Mr. Stekoll explained.

"The full impact of this program and its present and future contribution to our company is yet to be measured," he concluded.

Stekoll Petroleum Corporation, publicly-owned since April, 1959, operates in this area, through two limited partnerships, from its district office in Perryton, Texas. Executive offices are in Dallas, with international operations currently underway in Canada, Venezuela and Trinidad.

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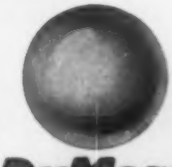

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ASSOCIATION OF OIL WELL SERVICING CONTRACTORS

Baker Hotel, Dallas, Texas, January 14-16, 1960

THURSDAY, JANUARY 14

10:00 A.M. MEETING: Board of directors and outgoing chapter chairmen
TEXAS ROOM: Mr. J. C. Williams, Jr., AOSC president, presiding

12:00 NOON LUNCHEON: Board of directors outgoing chapter chairmen and wives
LOUNGE ROOM: Mr. James E. Danheim, AOSC executive secretary, presiding

2:00 P.M. MEETING: Board of directors and chapter chairmen
TEXAS ROOM: Mr. J. C. Williams, Jr., AOSC president, presiding
REGISTRATION ON MEZZANINE

FRIDAY, JANUARY 15

8:00 A.M. BREAKFAST: LOUNGE ROOM

8:30 A.M. REGISTRATION ON MEZZANINE

9:00 A.M. GENERAL SESSION: CRYSTAL BALLROOM:
Mr. J. C. Williams, Jr., AOSC president, presiding
Invocation: Mr. J. F. McAdams, d/b/a General Oilfield Contractor, Hobbs, New Mexico
Welcome to Dallas: Honorable R. L. Thornton, Mayor, City of Dallas
President's address: Mr. J. C. Williams, Jr., Crusaders Drilling and Service, Inc., Springhill, Louisiana
Treasurer's Report: Mr. Barney Foster, F & F Well Service, Odessa, Texas
Executive Secretary's Report: Mr. James E. Danheim, AOSC, Dallas
Nominating Committee Report: Mr. J. F. McAdams, Chairman
Other Committee Reports
Key-Note Speaker: To be announced
Ethics, Functions of Local Chapters and Problems of Local Chapters: Mr. Walter W. Voges, assistant to the executive secretary of AOSC
LADIES COFFEE: DANHEIM SUITE: 9:00 until 11:30 A.M.

12:00 NOON LUNCHEON: LOUNGE ROOM
Mr. James E. Danheim, AOSC executive secretary, presiding
ENTERTAINMENT

2:00 P.M. GENERAL SESSION: CRYSTAL BALLROOM:
Mr. J. C. Williams, Jr., AOSC president, presiding
Panel Discussion: Needs and Problems of Insurance for Well Servicing and How Safety Can Help Your Insurance Program, Mr. B. A. Woolery, Argonaut Insurance Company, Menlo Park, California and Mr. Stanley Draper, Dallas
Where Do We Go From Here: Mr. Ab Sutcliffe, ROWSCO, Inc., Russell, Kansas

4:00 P.M. ASSOCIATE MEMBERS MEETING: CRYSTAL BALLROOM: Mr. Knox Egan, Wilson Supply Company, Wichita Falls, Texas, presiding chairman
CHAPTER CHAIRMEN, VICE-CHAIRMEN AND SECRETARIES JOINT MEETING
ENGLISH ROOM: Mr. Walter W. Voges, AOSC, presiding

6:00 P.M. HOSPITALITY HOUR: TERRACE ROOM

8:00 P.M. BUFFET DINNER-DANCE: TERRACE ROOM

SATURDAY, JANUARY 16

8:00 A.M. BREAKFAST: LOUNGE ROOM

9:00 A.M. GENERAL SESSION: CRYSTAL BALLROOM: Mr. J. C. Williams, Jr., AOSC president, presiding
Problems of Producers as They Affect Relations Between Themselves and Oil Well Servicing Contractors: Mr. Gordon Simpson, Dallas
Nominations of Officers from the floor

12:00 NOON LUNCHEON: LOUNGE ROOM
Mr. Ralph L. Clarke, Clarke Oil Well Servicing Company, Inc., Hobbs, presiding

2:00 P.M. GENERAL SESSION: CRYSTAL BALLROOM
Mr. J. C. Williams, Jr., AOSC president, presiding
Election of Officers
LADIES COFFEE: LOUNGE ROOM

3:30 P.M. ORGANIZATIONAL MEETING OF NEW BOARD OF DIRECTORS — ENGLISH ROOM

6:00 P.M. HOSPITALITY HOUR: TERRACE ROOM

8:00 P.M. ANNUAL BANQUET: TERRACE ROOM
Mr. J. C. Williams, Jr., AOSC president, presiding
Awards
Presentation of New Officers
Speech by New President
Entertainment and dancing

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Interpretation of AIR-DRILLED SAMPLES

Analysis of cuttings obtained while drilling with air can furnish unequalled information about the formation — and in the least amount of time

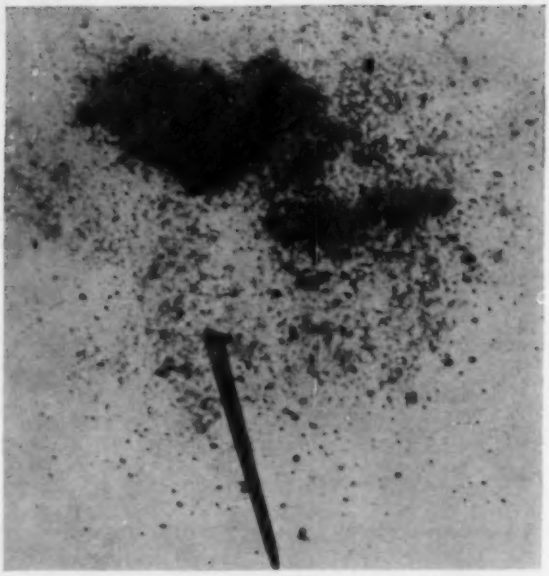

FIG. 1. **Air-drilled sample** of St. Peter sand, an Arkansas well. Single nail illustrates particle size.

John K. Petty
Consulting Geologist
Farmington, New Mexico

AS AIR AND GAS drilling becomes more important and more economical, the proper geological interpretation of samples drilled while using these circulating media also becomes more important. The sample cuttings drilled with air are probably the most nearly true representation of the formation — and it is certainly the most easily and quickly available.

There are, however, many horizons which are drilled through with *no* samples saved because the interpretation *seemed* unimportant at the time — only to be reviewed with regret in the light of future needs for well data.

Valid interpretation of samples while drilling with air or gas can be obtained with little effort by following a few basic rules and developing a routine sampling technique.

The drilling superintendent and the geologist must work together so that reasonable material for interpretation can be expected. If the geologist follows a specific procedure, and close attention is paid to the drilling time and time of ascent of the cutting to the surface is noted, proper interpretation can be assured. Such a procedure for sample-taking and sample interpretation is outlined here.

Taking the Sample

Good air samples will give a perfect representation of the formation being drilled that will be free of contamination — which cannot always be said of samples obtained through other media. It must be borne in mind, however, that any sample cannot be interpreted successfully if not properly taken. No matter how perfect a technique used, if the sample is not representative of the formation, the quality of interpretation will be nil.

After all is said and done, perhaps the best sampling container for use in air drilling is a large bucket, wherein cuttings can be caught at the end of the flowline.

Where gas is being flared at the end of the flowline, samples are "cooked" in the open flame, and cuttings must be caught elsewhere in the flowline. It has been found that a 2 or 3-ft length of 2-in. pipe welded to or coming out of a tee on the flowline will suffice. A valve should be located near the end of the 2-in. pipe. This sampling "jet" can be improved by inserting a metal baffle inside the tee and immediately below the downstream side of the 2-in. The baffle should be made slightly wider at the top grading to smaller at the base so that the heavy and lighter particles will be captured in a like proportion as they were drilled in the formation.

When cuttings are taken from a sampling arrangement of this type it would be well to remember that cutting contamination can be eliminated and accumulation of cuttings from several feet of drilling can be held to a minimum if the line is purged before the sample is taken.

Considerations for Sample Descriptions

It is very difficult to describe air drilled samples in the open air and should be checked in as still a place as possible for best results.

The time to be spent in the interpretation, of course, will depend on how much detail is required. It has been found that a microscope equipped with a 9, 18 and 27 power lens is satisfactory.

A question may arise if particles suddenly grade to a smaller size for no apparent reason. Was this sample reground because of load increase in cuttings due to faster drilling or momentarily diminished air volume?

The sample interpreter should pre-

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pare himself as thoroughly as possible in the stratigraphy of the region and the characteristics of the formations from which he will interpret samples. The fracture of the particle is an important characteristic.

Drilling time is of course an invaluable aid for determining formation changes, possible porosity, dull bits, etc.

The interpretation technique discussed is used independent of knowledge of drilling time or of air pressure and volume. These factors are usually checked after the sample has been described since an overall technique for interpretation was being pursued. The result is that it has been found that interpretation can be accomplished by pure geology if the sample is a true one. For this reason a discussion of constant air volume, size of hole, constant pressure, the different volumes of air for different hole sizes, bit nozzle size, and sample return time will not be undertaken.

Sample Interpretation

The collected sample should not be agitated, and is best cut with a tablespoon. One-eighth of a tablespoon full of sample can be spread over a clear round glass tray in such a manner as to enable careful study of individual particles. This seemingly small amount of sample is ample for most descriptions.

Three-Phase Analysis

After studying the dry sample, the second step in analysis may include an acid test. By applying a 5 to 10 percent solution of hydrochloric acid, calcareous particles may be detected. This should be done, first, by using just enough acid to totally dampen the particles, and second by an acid bath as desired. Do not confuse casing cement, bit fragments or air bubbles with the presence of calcareous material. Much of the effervescence will be microscopic. If possible the casing program should be known in advance, so that the geologist may be alerted for cement ground into small dusty particles.

After the sample has been viewed dry and with acid, water should be allowed to run indirectly into the sample tray in such a manner as to float off the fine dust skim formed by the acid. If necessary, the tray should be left still for a moment to insure proper settling. The remaining water should be poured off, and if need be, the washing process should be repeated.

CHARACTER, RESPONSE OF GENERAL LITHOLOGY TO AIR DRILLING

Since limestone and dolomite, shale and siltstone, sandstone and chert with

1.

OTIS SURFACE SAFETY VALVES

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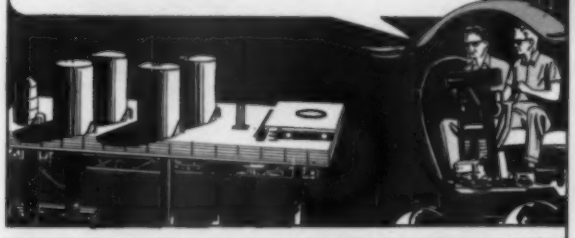
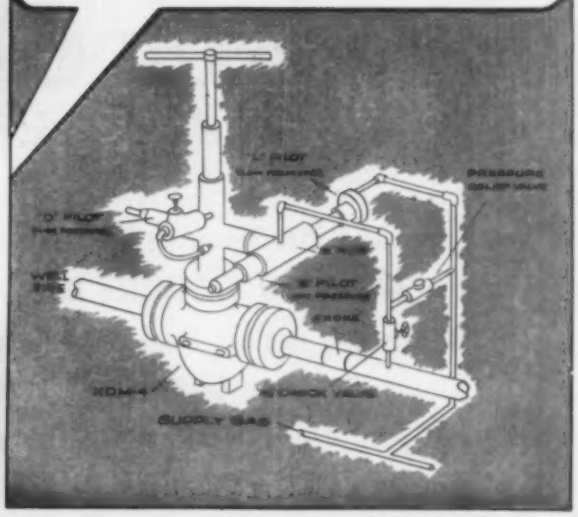


2.

HERE'S A DIAGRAM OF THE SAFETY VALVE AND AUTOMATIC PILOT INSTALLATION WE HAD ON THIS PLATFORM. EACH OF THE SIX WELLS HAD A TYPE XDM-4 OTIS SURFACE SAFETY VALVE INSTALLED BETWEEN THE WING VALVE AND THE CHOKE. THE SAFETY VALVES AND PILOTS WERE INSTALLED SO AS TO (1) SHUT IN AN INDIVIDUAL WELL SHOULD A FREEZING CONDITION EXIST IN A FLOW LINE OR CHOKE; (2) SHUT IN ALL WELLS ON THE PLATFORM SHOULD A FLOW LINE BREAK, OR (3) SHUT IN ALL WELLS ON THE PLATFORM SHOULD THE GAS SALES LINE BREAK, OR SHOULD SOMETHING HAPPEN TO ANY OF THE AUXILIARY EQUIPMENT ON THE PLATFORM. IN THIS CASE IT WAS HIGH TEMPERATURE ON A HEATER THAT ACTIVATED A TYPE L OTIS PILOT TO SHUT IN ALL THE WELLS.

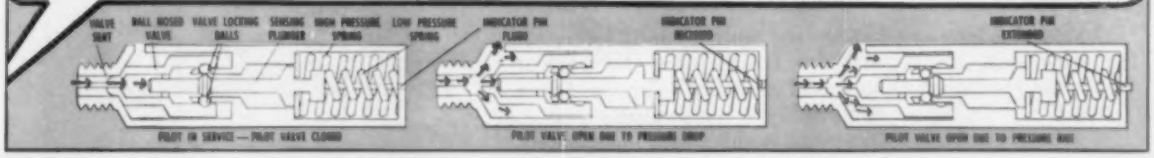


3.

THE SIX WELLS WERE PRODUCING 32 M.M.C.F.D. WHEN AN EQUIPMENT FAILURE BOOSTED THE TEMPERATURE IN ONE OF THE HEATERS TO ABOUT 1,000° F. THIS SET THE PLATFORM ON FIRE. BUT WE DIDN'T LOSE OUR WELLS OR THE PLATFORM — THANKS TO THE OTIS SAFETY VALVES. WHEN OUR PUMPER GOT OUT THERE HE FOUND ALL OF THE WELLS SHUT IN, AND ONLY A SMALL FIRE BURNING, WHICH HE EXTINGUISHED. AFTER MAKING LIMITED REPAIRS, THE SAFETY VALVES AND PILOTS WERE RESET AND THE WELLS PUT BACK ON PRODUCTION.

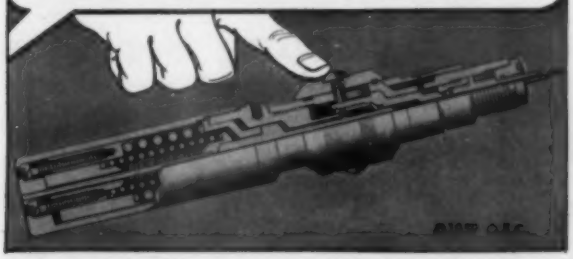
4.

SPEAKING OF RESETTING PILOTS, HAVE YOU SEEN THE NEW TYPE E OTIS HI-LO PILOT? IT'S SO SIMPLE TO SET AND RESET A TEN-YEAR-OLD BOY COULD DO IT. HERE ARE THREE SCHEMATIC DIAGRAMS OF THE TYPE E, SHOWING THE PILOT IN ITS THREE OPERATING POSITIONS: SET AND READY TO OPERATE; OPENED AS A RESULT OF A PRESSURE DROP; OPENED AS A RESULT OF A PRESSURE RISE. THE NEW TYPE E PILOT HAS MANY FEATURES WE LIKE. TO LIST A FEW — IT'S QUIET. THERE'S NO LOUD POP WHEN IT OPENS. THEIR STANDARD MODEL IS RATED TO 8,000 P.S.I. AND WE CAN GET HIGHER PRESSURE RATINGS ON SPECIAL ORDER. THE TYPE E IS ADAPTABLE TO REMOTE CONTROL OR EXTERNAL CONTROL SYSTEMS USING ELECTRICITY, HYDRAULIC PRESSURE, OR MICROWAVE. YOU CAN TRIP THE PILOT MANUALLY WITHOUT ANY SPECIAL TOOLS. WE'VE FOUND THE PILOT ACCURATE TO PLUS OR MINUS 1%. IT HAS A VISUAL INDICATOR TO TELL YOU WHEN THE PILOT IS LOCKED OUT OF SERVICE, AND ANOTHER INDICATOR TO TELL YOU WHETHER THE PILOT OPERATED DUE TO A PRESSURE RISE OR DROP.



5.

TO GET BACK TO RESETTING THE TYPE E OTIS HI-LO PILOT — HERE'S ALL YOU DO. AFTER THE PILOT HAS OPERATED YOU TWIST THIS RESET COLLAR TO THE RIGHT. THIS CLOSES THE PILOT AND EXPOSES A RED BAND, WHICH IS A VISUAL INDICATION THAT THE PILOT IS LOCKED OUT OF SERVICE. WHEN THE INDICATOR PIN IS FLUSH WITH THE END OF THE PILOT YOU CAN PUT THE WELL BACK ON PRODUCTION BY TWISTING THE RESET COLLAR TO THE LEFT. WE'LL BE USING A LOT OF THESE PILOTS IN THE FUTURE BECAUSE OF THEIR SIMPLICITY AND MANY ADVANTAGES.



6.

THE OTIS SURFACE SAFETY VALVES AND PILOTS WE INSTALLED ON OUR PLATFORM ONLY COST $6,500. THAT'S A PRETTY SMALL INVESTMENT TO PROTECT A SEVERAL-MILLION-DOLLAR INSTALLATION. AND THIS ISN'T THE FIRST TIME OTIS SAFETY EQUIPMENT HAS SAVED US A SUBSTANTIAL LOSS. EXPERIENCE HAS TAUGHT US WE CAN RELY ON OTIS SAFETY EQUIPMENT. IF YOU HAVE **ANY UNPROTECTED WELLS** — ESPECIALLY IN ISOLATED LOCATIONS OR IN CRITICAL AREAS — I SUGGEST YOU CALL YOUR NEAREST OTIS OFFICE NOW. LET AN OTIS SAFETY VALVE EXPERT HELP YOU WORK UP THE PROPER SAFETY PROGRAM FOR YOUR WELLS—**TODAY—BEFORE YOU NEED IT.**

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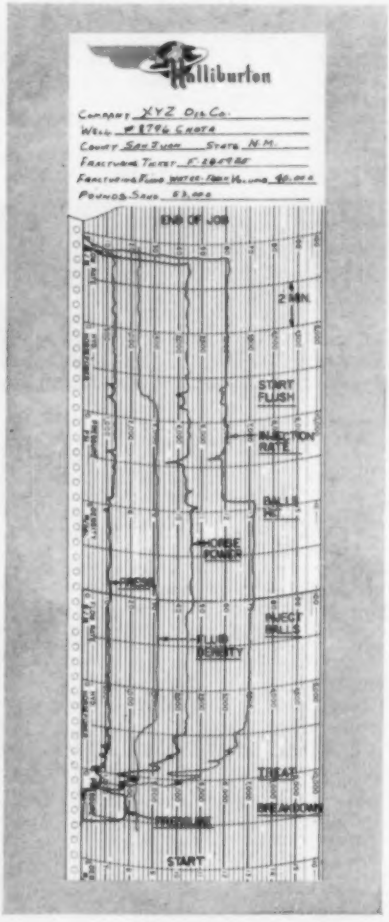

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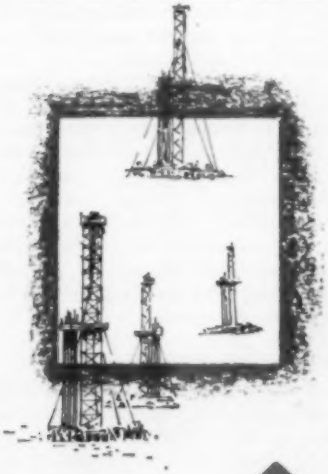

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their multitudinous variations, are the most common formations penetrated in the ever increasing petroleum search in the sedimentary section, a few observations observed in the interpretation of air drilled samples will be mentioned.

Limestone

Hydrochloric acid is obviously an invaluable aid to identification of limestone in samples both megascopically and microscopically but never has it been so highly regarded as when trying to determine calcareously cemented sandstones (mentioned again later) and limestones in such fine particles as only air drilling can cut them. It would be impossible to positively identify a very high percent of calcareous particles without it, unless they are of larger size than is common. The usual size of the air drilled limestone particle will grade ordinarily from common straight pin point size to straight pin head size with the greater percentage being smaller than half pin head size with occasional particles being twice larger than a pin head.

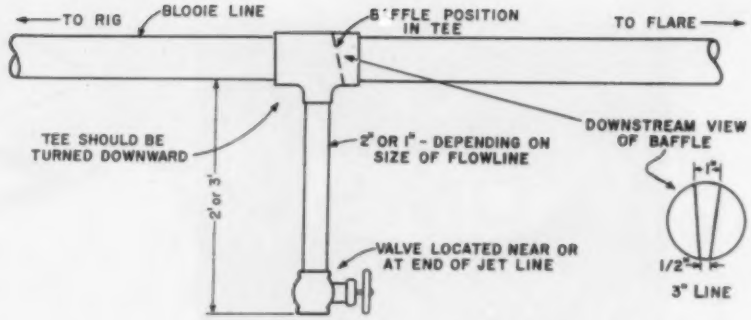

FIG. 2. **Air-sampling jet** on blooie line is suggested in this schematic diagram.

Problems to keep in mind are the possibility that the material examined may only contain a fraction of the lime drilled; therefore, it is important to check the air pressure or volume, sample return time, drilling time, and an estimate of bit condition by hours used and formations being drilled after an attempt has been made to positively identify the sample.

Silty and sandy lime and chalky lime can be difficult as the former may cause momentary speculation and confusion as being very fine calcareous sandstone and siltstone, and the latter may be only 10 percent present since it will be so light and fluffy and capable of being blown away easily.

If the limestone particle is large enough and the existing pores are small enough to be contained in its entirety, then porosity can be seen. If the limestone is chalky then it can be said to have porosity.

If a particle suggests that it is part of a vug or of possible cavernous porosity, exact information on porosity and permeability can be given only by coring the formation.

Dolomite and "Dolomitic"

In identifying an air sample of dolomite, one should closely observe its likeness to sand (if sandy dolomite), and its slower reaction to hydrochloric acid than limestone. If slightly sandy or granular its chances for porosity should be observed closely. If acid is not used, the possibility of cement in sand causes the sand to be called dolomitic sand instead of sand with sili-

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ceous cement. This important point should be taken into consideration when determining whether development treatment will be acid, or hydrofracing or nitroglycerin.

Sandstone

In order to determine the cementation of sandstone it is well to moisten the grains with hydrochloric acid to determine whether calcareous or not. The presence of calcareous cement may act as base, top or otherwise mark an interval in a formation. It will tell whether the sand will acidize profitably or not, should this knowledge be necessary in case acid or fracture treatment be considered. In many instances with air samples the calcareous cement will be seen to effervesce or it will cause a cluster of three or more to disintegrate into separate grains. In this case the true mechanically undisturbed grain shape and size can be studied as thoroughly as is desired.

Sandstone, if quartzitic, will tend to break into sub-angular grain shape. As to size of particle broken off of hard, bedded quartzite or hard quartzitic sand, it will depend on the air pressure used, the revolutions per minute of the bit and the weight used in the drilling.

Sandstone, if quartzitic, will tend to break into sub-angular grain shape. As to size of particle broken off of hard, bedded quartzite or hard quartzitic sand, it will depend on the air pressure used, the revolutions per minute of the bit and the weight used in the drilling. Porous sand with medium sized sub-round grains can usually be identified accurately. The sub-round grains, even if shattered, will still show a concave side on whatever piece of the grain is being examined. This rounded surface will indicate a sub-round or round grain. On the other hand in a particle with a sunken-in place showing a convex surface inside, you can suppose that a sub-round grain was dislodged from that particular area of the particle. When a small quantity of sample particles is thoroughly viewed, ordinarily if one or two medium sub-round grains are found there will be many more. If this condition exists and calcareous cement is in evidence then usually porosity exists. If all the sand grains are found as single grains and some of them are sub-round, this will be indicative of porosity. The fact that the whole grain remains, shows the formation is soft enough that the particles do not have to be completely shattered to be drilled out.

If the particles are sub-angular or in fairly large particles or chunks up to twice pin head size and appear to have been shattered or ground or chipped into the shape they are in then there is not much chance for porosity to exist. This statement would not apply to reground samples.

Shale and Siltstone

Pure and nearly pure shale drill faster with air. One 20-ft interval of very fine silty shale was observed to drill at the rate of 2 ft per min.

Usually there will be a few lumps of twice pin head size in a shale sample even if 95 percent of the sample is finely cut into dust particles of pin point size.

If shale has very minute and a minimum of silt grains evenly distributed throughout, it has been observed to drill the fastest. When it is pure it has been observed to be penetrated at the rate of one to one and one-half minutes per foot. When shale is very silty it can be very hard and require many minutes per foot for pentration. Siltstone usually drills very slow and wears the bit unmercifully.

If a shale is pure, it can easily be recognized if moistened only by acid, or by wetting it with water. If there is much silt in the shale there will be some grains in a matrix of shale and a silty shale can be identified. If the silt is well apart from the shale particles or dust and if grains are not embedded in shale, then likely a bed of siltstone has been drilled through. Again, a thorough knowledge of the stratigraphy and of the particular member the sample is from will be of inestimable importance in proper interpretation. A shaly siltstone, a hard silty shale and a siltstone all are closely related.

Chert

Chert is not difficult to identify as there will usually be fragments in which one can observe the kind of fracture as well as color, texture, etc. as the hydrochloric acid or water is applied.

It seems to shatter better than many formations since it is hard and brittle, however there will be much chert dust as in other formations. These dust and small pieces will of course all be insoluble in hydrochloric acid, if pure chert. And by aid of an 18 power lense, if necessary, these particles can be studied and easily identified.

The particles will grade from smaller than pin point size to larger than two pin heads in size. The particle is sometimes approximately the same in length and breadth, but more often it will be in slivers and in shapes measuring more in length than in breadth.

To be embedded in an air drilled limestone sample, the chert particle must be very small. More often it will be found as a loose particle, apart from its matrix, having been separated when drilled out, this usually being the case if all the particles are smaller than average or one third pin head size.

GENERAL DESCRIPTION OF SAMPLES

The writer has studied air and gas drilled samples in several active areas in different states and finds that the following type descriptions can be arrived at in air and gas drilled sample interpretation regardless of what member the limestone, sandstone, dolomite, shale and siltstone and their variations occur in.

The method has a very general application, and can be used in any sedimentary area. The following descriptions, however, have been made by examining air drilled samples in specific formations.

Hartshorne shale and sandstone can be described as being a dark gray to very black shale and a light gray also at times white, fine to medium sub-round to sub-angular, unconsolidated to consolidated sandstone, sometimes containing small to medium to large, sub-round to round, frosted to clear quartz grains. Coal, iron rust, and iron pyrite were also identified as being in the Hartshorne.

Atoka shale and sandstone consist of hard and soft medium gray to black, sometimes silty, sometimes pyritic, at times calcareous shale which occasionally is found graded into very hard siltstone. The sandstone is at times hard, sub-angular, quartzitic, consolidated, then at other times soft, unconsolidated, porous, sub-round, calcareously cemented. It is shaly at time and can have fine silty particles in it. Clear and frosted quartz grains of small to large sizes have been identified.

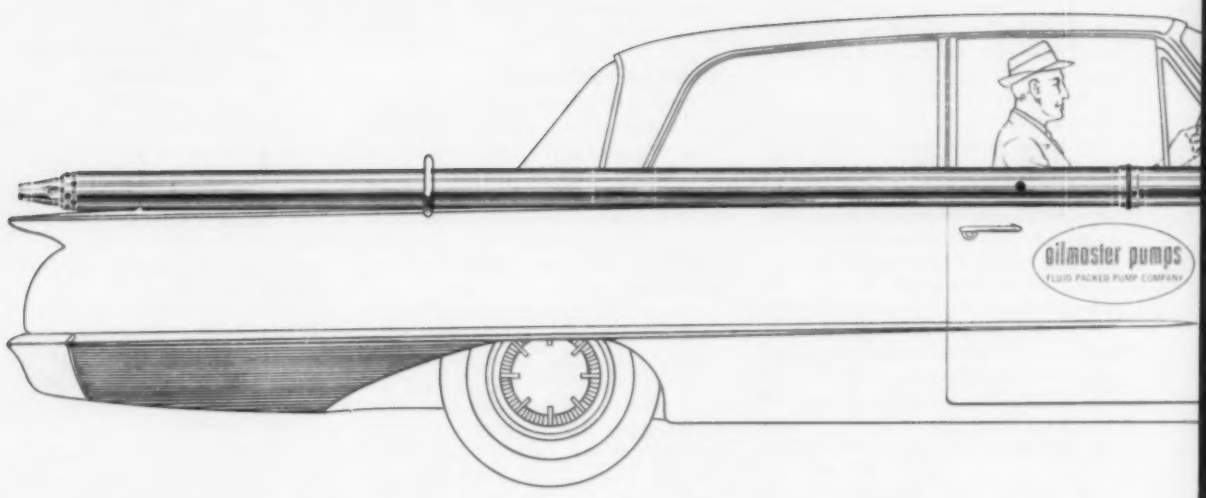
No fossil fragments have as yet been recognized as such in the Atoka air-drilled samples and they have been identified in mud drilled samples of same formation.

Bloyd. The base of the Atoka and top of Bloyd formation is called — in this interpretation — by presence of calcareous cemented sandstone and lime detection of which has not been too difficult by using hydrochloric acid.

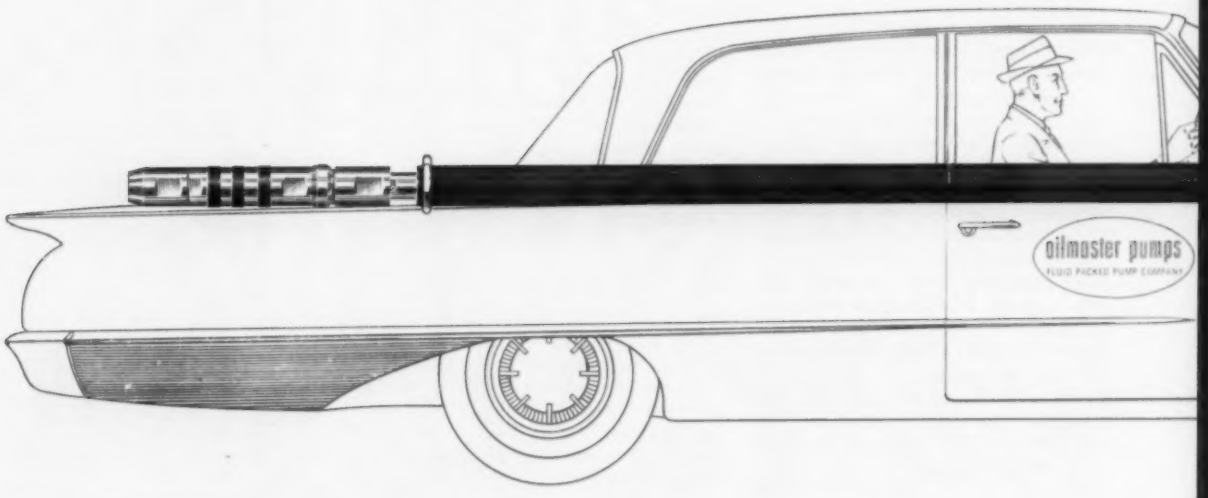
Bloyd is a very dark gray to black silty shale. The lime in it is a white to tan, fine crystalline limestone. A small amount of white, light gray, sub-angular, medium-grained sandstone is present in the Bloyd.

Kessler limestone was called when this Bloyd section became pure limestone without the sand and shale. The limestone is described as white, gray, tan and brown fine crystalline and chalky. Some iron pyrite is found in this formation.

Brentwood limestone is a tan to gray fine crystalline limestone.



Which Car has the



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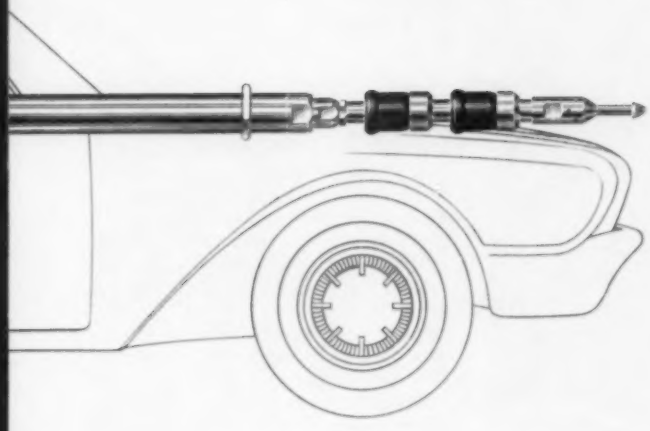
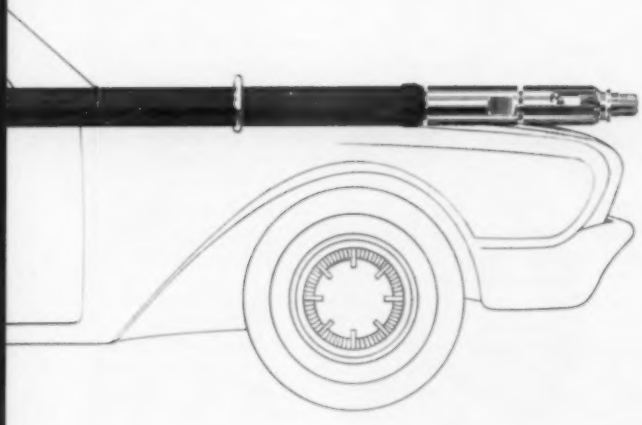


Guess again—This Fluid Packed Pump Co. field service car is delivering one of the new OILMASTER Subsurface Hydraulic Production Units. From outward appearance rod pumps and hydraulics look alike, but keep watching these OILMASTER cars closely and you will see an increasing number carrying the hydraulic. If you are operating subsurface hydraulic pumps now, or are considering a future hydraulic installation, ask your Oilmaster sales representative about the many outstanding features of this unit. Look at the specification sheet and compare the capacity, the pressure requirements, and the variety of models with other subsurface hydraulic production units. Then ask your Oilmaster sales representative about field service and on-the-spot repair in well equipped, strategically located pump shops.

Rod Pump?



You're right, it's this one! It's the same Fluid Packed Pump Co. field service car, but on this trip it is carrying an OILMASTER Sucker Rod Pump—The pump that has set the standard by which other pumps are judged. If you are talking hydraulics with your OILMASTER representative, don't forget he also can help you with a complete line of rod pumps and accessories including such OILMASTER firsts as the Three Tube Fluid Packed Pump, the One-Piece Hardened and Honed Barrel, the incomparable Unit Barrel, the Independently Landed Parallel String for Dual Zone Installations, the Ratio Compound Pump, the Tungsten Carbide Seat and Ball and the Vertical Setting Pump Anchor.

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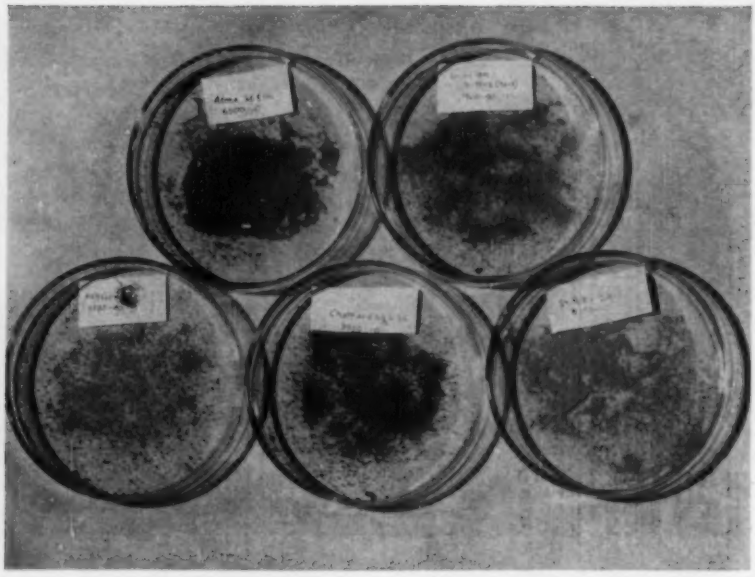


FIG. 3. **Samples** collected while drilling with air, showing difference in size in particles and coloring.

Hale is a gray tan fine crystalline limestone in its upper part and a clear to white, medium to large sub-round to sub-angular grained, mostly consolidated, calcareous cemented sandstone in its lower part which is termed the Hale porous zone and produces dry gas in several fields in the Western Central Arkansas River — McAlester Basin area.

Pitkin limestone is identified as a light gray to white, mostly tan and brown sometimes chalky, mostly fine crystalline limestone. No fossil fragments could be positively identified as such. The iron pyrite was observed, both macro-and microscopically.

Fayetteville shale was observed to be a black, silty, calcareous sometimes fissile shale.

Moorefield shale is a black and gray, hard, slightly calcareous shale.

Boone Chert is described as light gray and clear, some translucent.

Chattanooga shale is black, silty, calcareous and has mostly a conchoidal fracture.

Penters Chert is light gray, light bluish, clear and translucent and is conchoidal. The limestone associated with the chert in these air-drilled samples is light gray, fine crystalline and slightly cherty or siliceous.

Silurian is identified as a very white and light gray fine crystalline, sometimes fine granular, chalky in intervals, sometimes dolomitic, and at times cherty limestone.

Ordovician consists mostly of light and medium gray lime, fine to medium crystalline.

St. Peter Sand is a white, light gray, clear, mostly sub-round but some sub-angular, consolidated, some unconsolidated (in sample), some quartzitic, calcareous cemented sandstone.

A core sample of St. Peter was very hard, light gray, mostly clear, fine to medium, sub-round to round, hard, calcareous cement, partly quartzitic sand and clear quartzite. In some parts of the core, only dim outlines of grains can be seen leading one to believe that due to great compaction and stress many quartz grains have been changed into the dense translucent quartzite observed.

General Observations

In order to obtain better samples for interpretation in a region the geologist is unfamiliar with and there is no available data, then enough pressure and volume of the circulating medium should be maintained to deliver larger cuttings so the characteristics may be studied more fully. More pressure and volume will bring the cuttings out more quickly. This keeps the hole cleaner as well as prevents the cutting from being reground thus making it finer and finer, rendering interpretation more difficult.

Unless water is very strong in an interval, the gas pressure and volume can be increased so as to bring the cuttings out of the hole. True they will be wet but the procedure described can be used to interpret it whether dry or wet when it is taken. There are presently several new successful methods of drilling through water zones which one can read about in the petroleum periodicals. * * *

Southeastern Drills In Iran

THE SOUTHEASTERN DRILLING CORPORATION of Dallas has announced that an associated company, The Seacat Drilling Company, of Iran, S. A., has signed a two-year contract with the Consortium to conduct exploratory drilling operations in southern Iran. The rig to be used on this program is powered by three sets of quad diesel engines, and has two 700-hp pumps, together with all other necessary balanced equipment capable of drilling to 18,000 ft. The first well will be located approximately 12 miles east of the town of Bandar Abbas. Projected depth of the first well will be 15,000 ft.

The rig was assembled and fully tested in Houston. A ship carrying the rig was scheduled to depart from Houston on November 11, arriving at Bandar Abbas around December 10, 1959. All of the equipment, the drilling rig, camp houses, oil field trucks, and road building equipment will be unloaded by ship's tackle onto lighters and moved directly to the beach.

In addition to the drilling contract, the entire Marine and Civil Works contract is also to be handled by the drilling company. This includes construction of roads and the location, air strip, tank and warehouse construction, laying of water lines from the beach to the rig, off-loading the entire rig and delivery to the shore, construction of a 900 ft long quay as a permanent facility, and providing the marine transport for the shipment of all subsequent materials from Bandar Mashur to Bandar Abbas by barges or self-propelled vessels.

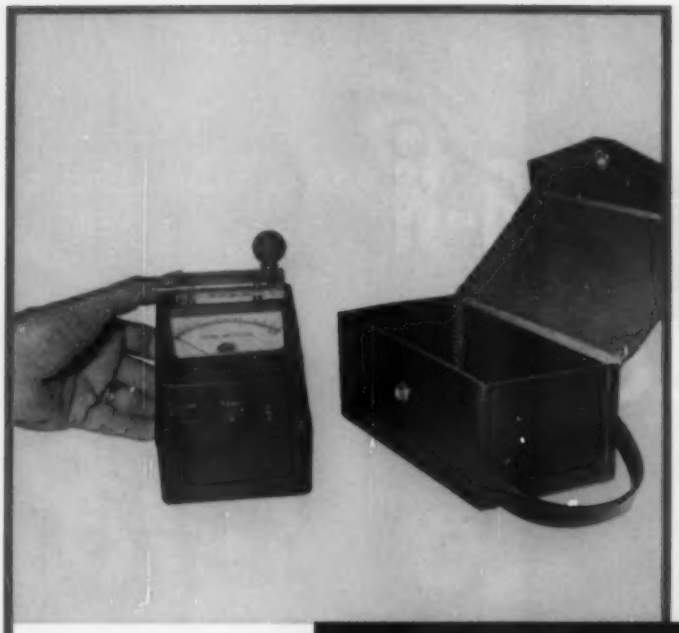
The first well will be spudded approximately January 10, 1960.

The Seacat Drilling Company of Iran, S. A., also owns and has had under contract for the past two years, two rigs in Iran for the Iran Oil Company and also operates a mobile barge for Pan American International Oil Company in the Persian Gulf which is now drilling below 2000 ft in water depth of 127 ft. Projected total depth for this well will be approximately 14,000 ft.

Don't miss the

OUTLOOK for 1960

beginning on page B-19



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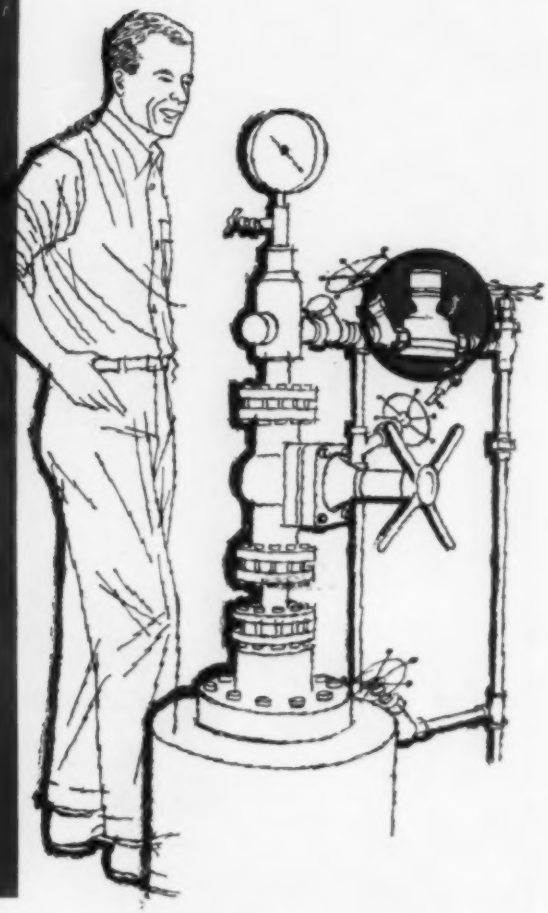

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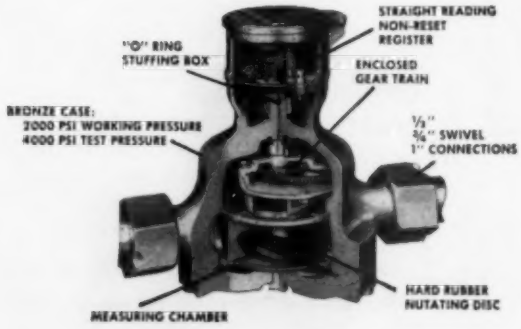
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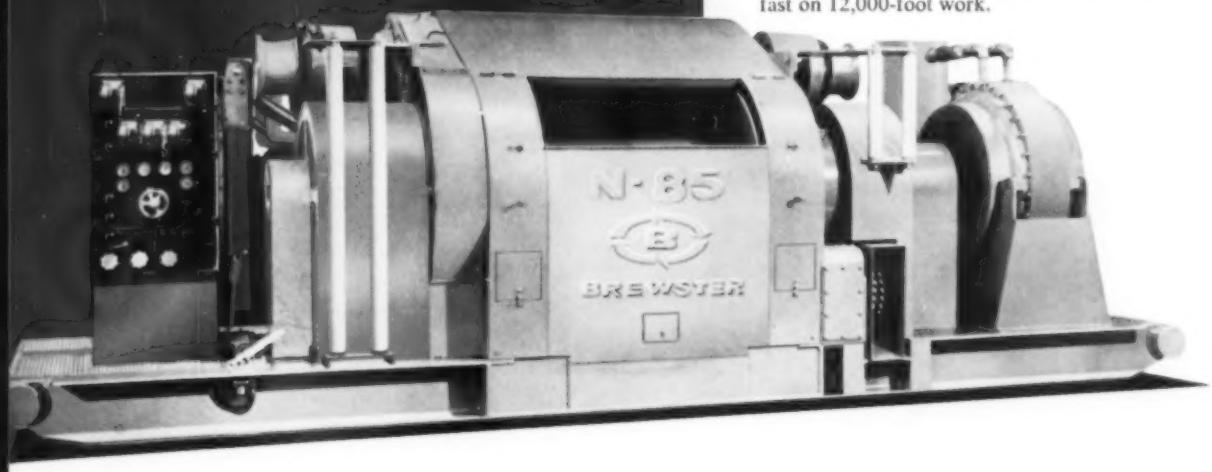

THE BREWSTER N-85

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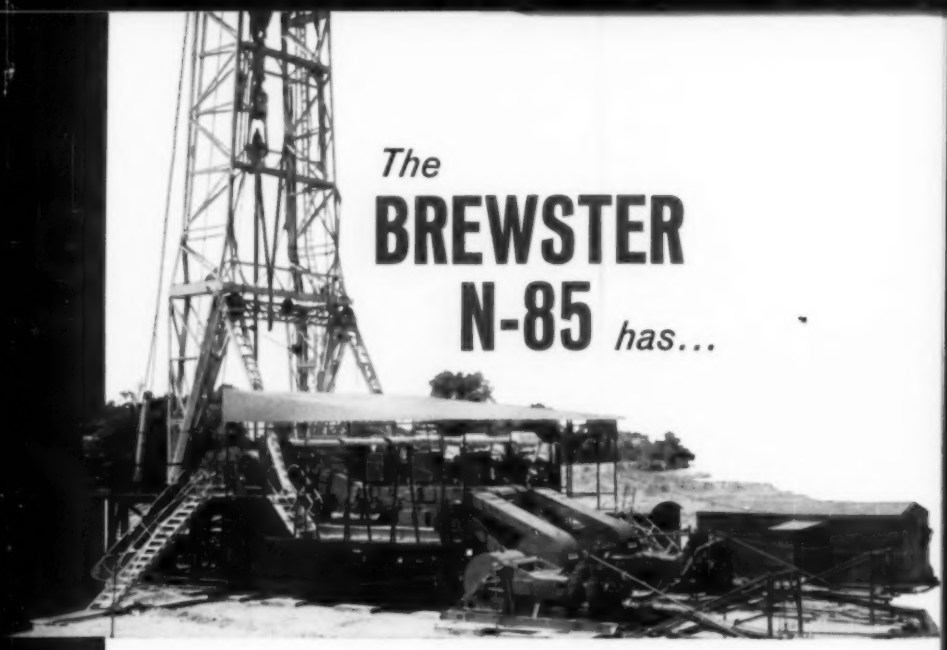

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Printed in U. S. A.

THE OASIS—

A gathering spot for NOMADS

New York: November 2 was the date of the usual monthly party of the New York Chapter of Nomads. Among the large number of guests and Nomads attending were the following out-of-town visitors: (first row, left to right) F. A. Chapman, Aramco Overseas Co., Australia; A. K. Baebel, Hughes Tool Co.; J. Birks, British Petroleum Co., Ltd.; B. Beverly, Arabian American Oil Co.; A. A. Ashton, Continental-Emsco, Dallas; (second row) R. P. Gaylord; Wagner Morehouse, Inc., Los Angeles; G. A. Caragilino, Y.P.F.A.; W. R. Brennan, Arabian American Oil Co.; H. R. Warman, Sinclair Oil Co.; J. E. Skipworth, Lucey Export Corp.

Chicago: Among the visitors at the annual luncheon meeting of Nomads in Chicago, November 9, was a group of officials from Petroleos Mexicanos. Included in the Pemex group were: Serapion Fernandez, Fernando Padilla, Gutierrez Roldan, Antonio Garcia Rojas, Alfonso Barnetche, Rafael Ortiz Mena, and Carlos L. Corcuera.

Houston: International guests at the November 16 meeting of the Houston Chapter of Nomads included: (first row, left to right) J. Koller, R. Liebl, and R. Oberhauser, Hubner-Mayer, Vienna; C. J. Panzer, Dowell, Germany; Walter Reisinger, Moboil-Austria, Vienna; Basilio Monticelli, Y.P.F., Buenos Aires; (second row) Hermann Sporker, O.M.V.; Vienna; F. L. Griffith, Gulf Oil of Libya, Tripoli; A. Watson, Qatar Petroleum Co., Dukhan, Qatar; R. C. Reed, International Petroleum Co., London; Mario Lafont, Y.P.F., Buenos Aires; Indalecio Pelaez, Y.P.F., Buenos Aires; H. L. Tu, Chinese Petroleum Co., Formosa; (third row) J. N. Biron, Bobest Eng. Co., London; J. E. Berry, A-Z Export, Maracaibo; Mano R. Gonzalez, Y.P.F., Buenos Aires; J. M. de la Garza, Perforode Latina, Mexico City; H. D. Hoopman, Ohio Oil Co. of Guatemala, Guatemala City; O. W. Ward, Tennessee Gas & Oil Co., Calgary; Raul N. Viglione, Y.P.F.

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RUNNING TOUR with MEN in the INDUSTRY

Daniel A. Painter has been employed as staff geologist in the geological department, Delhi-Taylor Oil Corporation. **John W. Baker** is a new member of Delhi's land department. He had worked in the legal and land department of Southland Royalty Company in Fort Worth.

New personnel and a promotion in the La Habra Laboratory of California Research Corporation are: **Donald P. Squier,** assistant professor of mathematics at San Diego State College, joined the company as research engineer in the Oil Recovery Division, and **T. C. Bergstrom,** from Long Beach State College, joined the Producing Technical Service Division as a research engineer. **Barney R. Treadway** recently completed requirements for the MS in chemical engineering at Princeton and has accepted a position as research engineer in the Producing Technology Division.

Dr. J. F. Chittum was promoted to senior research chemist, corrosion and production, also in the Producing Technology Division.

Hugh W. Swan has been promoted to production foreman at Hobbs, New Mexico, for Tennessee Gas and Oil Company, a division of Tennessee Gas Transmission Company of Houston. He was in the company's southwestern division headquarters at Midland, Texas, as division office supervisor.

Johnny Mitchell has been elected president and a director of the Jade Oil Company. Mitchell, a partner of the independent oil producing firm of Christie, Mitchell & Mitchell, of Houston, Texas, succeeds **Harry M. Frank,** who was named board chairman and chief executive officer.

Johnny Mitchell

H. M. Frank

Other officers elected include **H. L. Leach,** vice president and treasurer; **J. Roy Derrick,** vice president; **Paul A. Smith,** secretary; and **B. F. Clark,** assistant treasurer. Other directors include **Fred S. Thomson** of Los Angeles, California; **Royal M. Galvin** of Beverly Hills, California, and **Henry Beissner** of Houston, Texas.

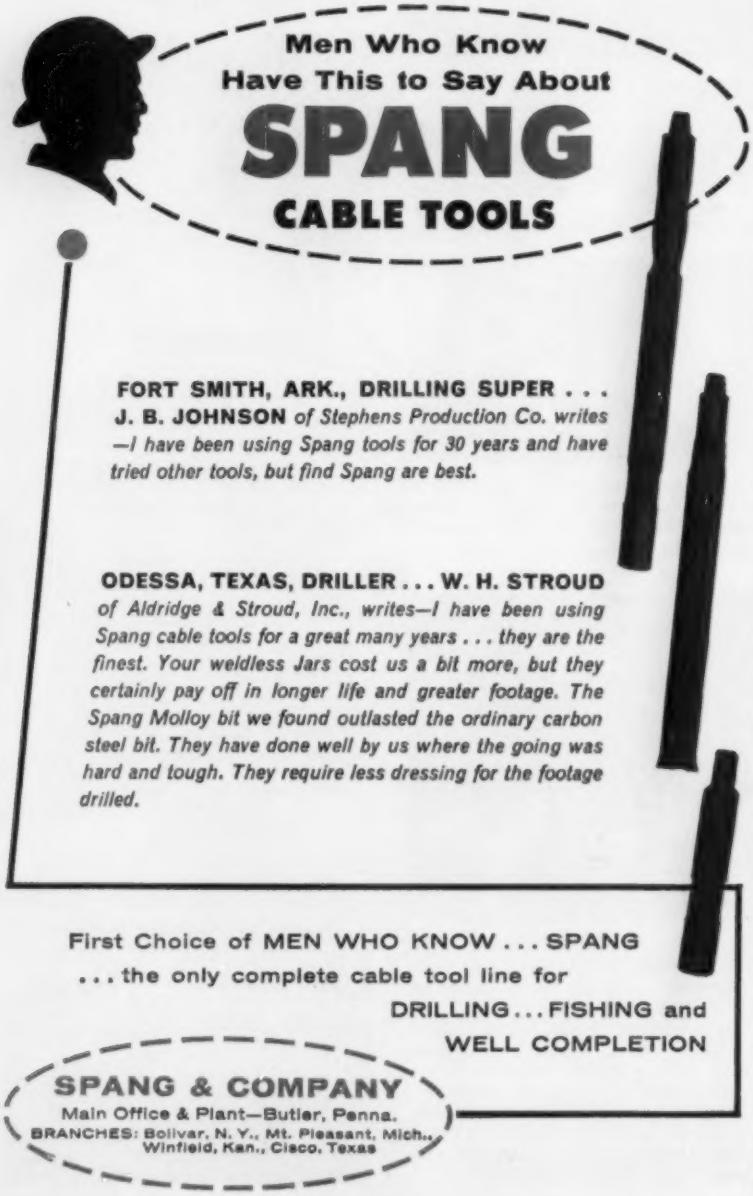
Several personnel changes in the exploration department of Kerr-McGee Oil Industries, Inc. are: **Gerald G. Loucks,** a district exploration geologist in Canada, is transferred to the company's Southern Rocky Mountain region office at Denver, Colorado. **Jon Palmer,** formerly junior geologist in Denver, has been transferred to the Oklahoma City office. **Harold Thurman,** geologist, has been transferred from Oklahoma City to the Southern Division office in New Orleans, Louisiana, and **Joe Hull,** formerly staff geologist in Oklahoma City, has been transferred to the Canadian Division office in Calgary, Alberta.

George R. Brown has been appointed assistant manager of the Texaco Exploration Company, a wholly-owned subsidiary of Texaco Inc. He succeeds **Roy Whisenhunt,** who has been transferred to Midland, Texas, to become assistant manager of the Midland Division of the domestic producing department of Texaco Inc.

George M. Schneider, formerly Rocky Mountain district manager, has been promoted to assistant to the president, The Sharples Oil Corporation. **Robin J. Corbett,** formerly assistant to the president, has been named coordinator, producing activities. It was also announced that the Midland, Texas, office has been closed and all matters formerly handled in Midland will now be handled out of the Denver office.

Albert T. C. Rutgers, of Calgary, Alberta, Canada, has been appointed gas supply and reserves representative for Western Canada for Northern Natural Gas Company. He replaces **W. E. Ainsworth,** who was assigned to Calgary temporarily last spring to establish the office, and has returned to Omaha.

Harold D. Hoopman, operations manager of The Ohio Oil Company of Guatemala, has been appointed resident manager succeeding J. Patrick D'Artois, deceased. **Arthur H. Petsch,** exploration manager for Ohio Oil of Guatemala, has retired with **Clark M. Shimeall,** chief geologist, succeeding him.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J. B. JOHNSON of Stephens Production Co. writes
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ODESSA, TEXAS, DRILLER . . . W. H. STROUD
of Aldridge & Stroud, Inc., writes—I have been using Spang cable tools for a great many years . . . they are the finest. Your weldless Jars cost us a bit more, but they certainly pay off in longer life and greater footage. The Spang Molloy bit we found outlasted the ordinary carbon steel bit. They have done well by us where the going was hard and tough. They require less dressing for the footage drilled.
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▸ Phillips Petroleum Company has announced promotions in its land and geological department. In the Bartlesville, Oklahoma, headquarters offices, **D. C. Hemsell** becomes assistant to **C. O. Stark**, vice president, land and geology, and **W. B. Weeks** succeeds him as department manager. **E. Van Den Bark**, southwest regional manager, succeeds Weeks as assistant department manager. **A. J. Hintze**, director of exploration, continues in his present position and in addition will assist in departmental management duties.

R. J. Haas, southwest regional geologist, is advanced to southwest regional manager. **T. H. Montgomery**, division manager at Lafayette, Louisiana, is transferred to Bartlesville and promoted to southeast regional manager succeeding **R. E. McPhail** who becomes staff geologist. **S. J. Talley** and **C. F. Lawrence**, division development geologists at Amarillo and Midland, Texas, respectively, are transferred to Bartlesville to become exploration geologist and development geologist, respectively, for the southwest region.

In the Lafayette division office, **S. A. Spencer**, assistant manager and division exploration geologist, becomes division manager; **C. W. McBride**, division landman, becomes assistant division manager and division landman; and **E. S. Hastings**, district exploration geologist, becomes division exploration geologist. **K. S. Blanchard**, division development geologist at Wichita Falls, Texas, is transferred to Midland, Texas, in the same capacity, and **K. M. Jastrow** is promoted from assistant division landman to division landman at Midland. **L. G. Williams**, assistant manager and exploration geologist for the Evansville, Indiana, division, goes to Billings, Montana, as division manager, and **M. A. Vaughan**, assistant division exploration geologist at Oklahoma City, Oklahoma, goes to Evansville as assistant division manager and exploration geologist. **B. S. Geho**, assistant division development geologist at Amarillo, is promoted to division development geologist.

▸ **John R. Spencer**, Houston, has been promoted to director of natural gas activities for Continental Oil Company's production department. Formerly engineering section chief in the production department, he will continue to make his headquarters in Houston and will succeed **J. W. Ferguson**, who recently was promoted to general manager of Conoco's newly established intrastate gas and gas products department. **F. B. Willson**, Houston, coordinator of natural gas sales since 1956, has been promoted to assistant director of natural gas activities and **B. L. Waggoner**, Oklahoma City, division engineer, has been named engineering section chief, reserves and evaluations, succeeding Spencer. Both men also will make their headquarters in Houston.

J. R. Spencer

▸ **Don F. Carlos** of Houston has been appointed executive assistant to **Thomas G. Kelliher**, manager of Tidewater Oil Company's home office exploration department in Los Angeles. Carlos has served as Tidewater's Southern Division exploitation geologist since July 1957.

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EXPLORATION ACTIVITIES

AFRICA

Huge Concessions Let In West Africa

Continental Oil Company and Cities Service Company have revealed in a joint announcement that contracts have been concluded for oil exploration on more than 10,000,000 acres in Senegal and Mauritania, West Africa.

In Senegal, Conoco and Cities Service will join two French companies, Societe Africaine des Petroles (SAP) and Compagnie de Participations, de Recherches et d'Exploitations Petrolieres (Coparex), in exploring for oil in the St. Louis and Richard Toll areas on concessions totaling more than 3,400,000 acres.

In Mauritania, Conoco and Cities Service will be associated with SAP and the Societe de Recherches et d'Exploitation de Petrole (Eurafrep) on a concession covering approximately 7,300,000 acres.

In Senegal, Conoco will own a 25-percent interest in the concessions, Cities Service, 24 percent, and the French companies, 51 percent. In Mauritania, Cities Service will own a 25-percent interest, Conoco, 24 percent, and the French companies, 51 percent.

TEXAS

Jackson County 'Cat Staked

A Jackson County wildcat has been staked by Houston independent operators Van Dyke & Mejlaender four miles northeast of Francitas. Their No. 1 H. H. Ray, a Frio test, is projected to 8600 ft or the top of the Vicksburg. ft is located two miles northwest of Midfields field. The operators have an 1100-acre block.

The test spots 467 ft from the north and west lines of the J. R. Beaumont Survey, just across the line from Matagorda County. Viking Drilling Company of San Antonio has the contract.

CALIFORNIA

Movie-Lot Discovery Tested From New Sand

Discovery of a promising new oil field on MGM studio property in Culver City, with a well that tested at a daily rate of 720 bbl of oil through a restricted choke, has been confirmed by Continental Oil Company. The well, the MGM No. 1, was drilled by Continental on Loew's, Inc. MGM studio lot and has been completed on temporary equipment to a total depth of 8807 ft.

Continental owns leases on approximately 850 acres of land surrounding the well. MGM property covers about 100 acres and is a part of Continental's leasehold block. Producing interval of the discovery is in a sand body different and unrelated to any producing sand in the nearby prolific Inglewood oil field.

Test Indicates New San Joaquin Valley Discovery

Formation test of a Tidewater Oil Company exploratory oil well has indicated a new San Joaquin Valley oil discovery. Located 12 miles south of Bakersfield, the well KCL 86-3 established a flow rate of 700 bbl per day of clean, 34-gravity oil and 815,000 cu ft of gas through a 32/64-in. orifice. The formation test was made from an interval between 8931 and 9014 ft in the Upper Stevens Sand. The well will drill ahead to a depth of 13,000 ft.

Tulare Lake Test Spudded

A new Tidewater Oil Company wildcat well was spudded on the east shore of Tulare Lake bed, the site of what was once considered the largest California lake at flood stages.

Known as Boswell-Richardson No. 72-10, the well location is on a block of about 8000 acres leased by Tidewater west of the town of Corcoran and north of the Trico gas field. Drilling is projected to a depth of between 11,000 and 12,000 ft.

LOUISIANA

Union Oil Tests Fourth Gulf Discovery

The Union Oil Company has made an important oil and gas discovery in the Gulf of Mexico on a 2500-acre tract, jointly owned by Union and Pan American Oil Company. This is Union's fourth consecutive discovery in the gulf. It is located on the Block 35 Prospect in the Vermilion area, 8 miles offshore from the Louisiana coast.

The well was drilled to a depth of 12,076 ft and was completed in two separate zones. The bottom interval was perforated from 10,604-630 ft and flowed gas at a rate of 3000 Mcf per day through 12/64-in. choke, with 3710 psi flowing pressure. The upper interval was perforated from 10,396-414 ft and flowed clean high-gravity oil at a rate of 370 bbl per day through 10/64-in. choke, with 1475 psi flowing pressure.

PHILIPPINES

Seismic Operations Continue In Islands

Century Geophysical Corporation, Tulsa, has been awarded a contract for a minimum of one year's seismic operation in the Philippine Islands for San Jose Oil Company, Inc. This seismic crew will be in addition to the four gravity crews that Century has been operating in the Islands for the past two years. Century's division offices are maintained in Manila.

AUSTRALIA

3,200,000-Acre Concession Granted in New South Wales

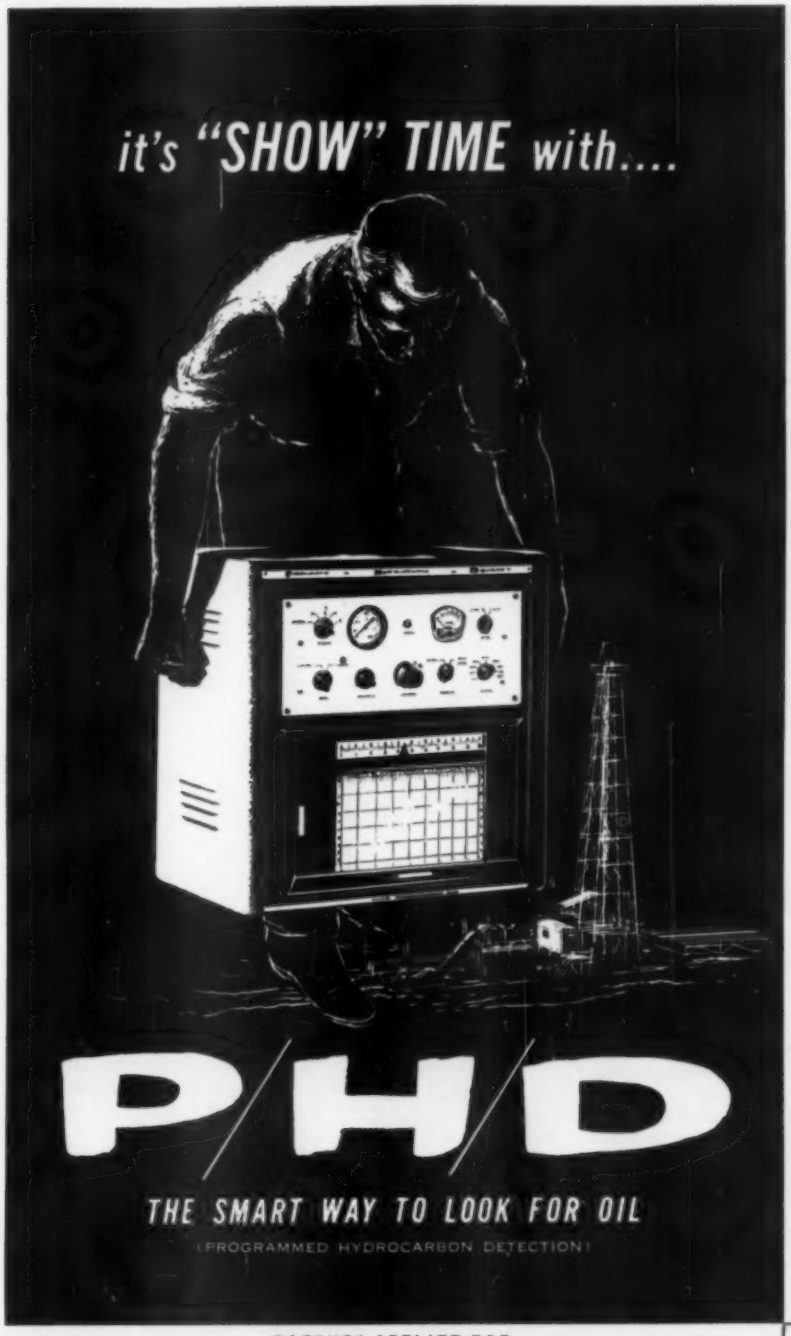
Texas American Oil Corporation of Midland has acquired an oil and gas concession covering a solid block of more than 3,200,000 acres in the state of New South Wales in Australia. Acreage covered by the concession is in the south end of the Great Artesian Basin and in the northwest sector of New South Wales. The concession is near the Lucky Strike spread on which Phillips Petroleum recently acquired a farmout.

A new wholly-owned Australian subsidiary corporation will be formed to explore and develop the acreage. Texas American also has filed additional applications covering several million more acres of oil and gas concessions. All acreage obtained in Australia will be put into the new subsidiary.

Joint Agreements Will Explore 60,000 Sq Miles

Union Oil Company of California and the Kern County Land Company have announced a joint program of exploration for oil and gas in a 60,000 sq mile area of southwestern Queensland and northern New South Wales. The two U. S. companies have arranged with Australian Oil & Gas Corp. Ltd. of Sydney to carry out an extensive exploration program on land held by the Australian corporation.

Geological studies and geophysical work will be carried out preparatory to selecting a site for a deep test well to be drilled in 1960. Under terms of the arrangement, Union Development Company, a wholly-owned subsidiary of Union Oil, and Kern County Land Company will jointly conduct and finance the program. Australian Oil & Gas will provide administrative services and staff to the joint project and will receive 20 percent of the profits from any production of oil and gas resulting from the venture.



Programmed **H**ydrocarbon **D**etector ... the hottest thing in mud logging!

Core Lab's new **P/H/D** eliminates the two biggest problems heretofore present in making chromatographic separations of hydrocarbon components—(1) the length of time required to completely "spell out" the heavier hydrocarbons; (2) the low concentrations of heavier hydrocarbons encountered (and the flattening out of heavy hydrocarbon peaks).

For example, **P/H/D** — utilizing an exclusive technique of back-flushing a single column after the desired hydrocarbon has been read — measures methane, ethane, and propane in 1-2-3 sequence (plus heaviers) in *only three minutes!* And, in the meantime, the column is automatically prepared for the next sample.

Heavier hydrocarbons which are normally encountered in low concentration can be grouped together. The width of the composite heavier component peak is compressed by back-flushing, making the peak on the recorder chart *higher and more apparent*. Result—fewer 'lost' shows.

Here, at last, is an electronic system for detecting and selectively analyzing *total gases* in rapid-fire order. And the beauty of it is **P/H/D's** simple put-together — sturdy, compact, dependable.

The Core Lab sales engineer in your area is equipped with **P/H/D** photos and detailed information. Give him a call. You'll be glad you did.

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CORE LAB

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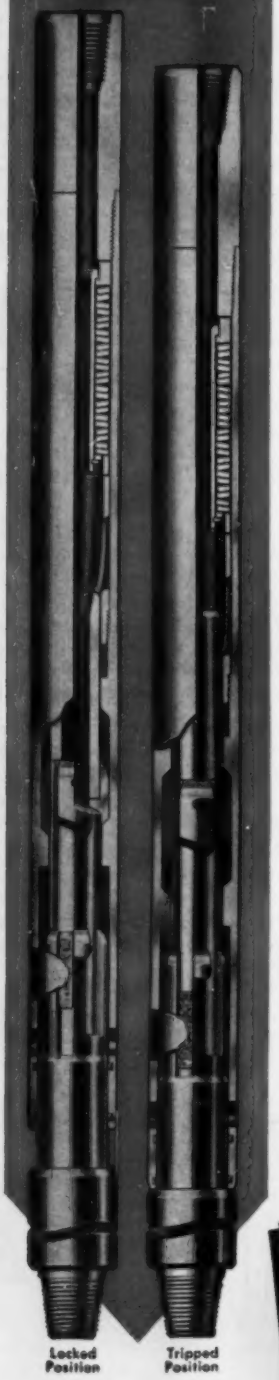
For running in the drill string . . .

Positive JAR-DOWN ACTION

. . . plus Safety Joint protection!



See the Shaffer section of your Composite Catalog.

THE SHAFFER-WAGGENER BUMPER SAFETY JOINT

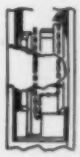
There is no other tool like the Shaffer-Waggener Bumper Safety Joint. It combines—in ONE tool—a choice of *jar-down* and *releasing* actions, both under complete control of the operator. What's more, the tool is so rugged it is run as part of the drill string to protect against stuck pipe.

In actual well service it has operated easily at depths below 18,000 feet, and has given no operating problems even in directionally-drilled wells with extreme slant.

Jar-Down Action

▶ **RUN IT IN THE DRILL STRING**—It is specifically designed to withstand the continuous vibration and heavy torque loads of today's drilling operations.

▶ **TO JAR DOWN** whenever the drill pipe threatens to stick—or to drive drill collars out of keyseats and to free "balled-up" bits—simply slack off weight equivalent to about 2,000 feet of drill pipe onto the tool. This releases the tripping mechanism, automatically striking a sharp down blow. Raising the string automatically re-sets the tool for another blow—and blows can be struck repeatedly as fast as the string can be raised and lowered. And no torque or twisting strains are placed in string!


Releasing Action

▶ **TO RELEASE,** in the event jarring will not loosen the stuck string, simply trip the tool and apply reverse torque as the string is slowly raised. Only one-sixth turn of the tool rotates the drive keys into unlocking slots so that complete release is effected by continuing to raise the string.

ANOTHER ADVANTAGE—the tool transmits full torque loads in *either* direction through three rugged drive keys—not through easily-damaged threads. It is the strongest joint in the string—not the weakest, as with conventional safety joints.

Also, the tool can be re-connected again by simply lowering the top portion over the lower portion and reversing the releasing action. It is ideal for use in fishing strings!

Exploration

CANADA

Crusade Tests Gas Field

Crusade Petroleum Corporation Ltd. has staked the location for the drilling of a test well on its 20,000-acre petroleum and natural gas reservation in the South Provost area of Alberta. The well, Crusade Sedalia, 7-7-32-4, is slated as a test for the northeast extension of the Grassy Island Lake natural gas field discovered by the California Standard Company.

The location was selected after an extensive subsurface geological study of the company's holdings in the area. The well will be drilled approximately ⅛ of a mile from the Alberta Gas Trunk Transmission line which traverses the property for a distance of 6 miles.

Freeze-Up Will Start Near-Arctic Drilling

Drilling for oil 180 miles south of the Arctic Ocean was slated to start immediately after freeze-up, announced Canadian Devonian Petroleums. The company holds a 15 percent interest in Crown permits in the Northwest Territories covering 3,500,000 acres. During the summer, a drilling rig was moved down the Mackenzie River to a location on the acreage 170 miles northwest of Norman Wells.

ALGERIA

Test Spudded In Algerian Sahara Near Morocco

The first test well to be drilled in the Algerian Sahara for the Societe des Petroles de Valence, in which the British Petroleum Group has a 50 percent interest, has been spudded in at El Arich el Megta, in the Djorf el Atfal permit area. This area, in west Algeria about 65 miles from the Moroccan border, was granted to the Societe des Petroles de Valence in August, 1958. The Societe holds exploration permits covering four areas totalling 17,800 square kilometers in the Algerian Sahara.

TURKEY

Gulf Begins Its First Well in Turkey

Turkish Gulf Oil Company, a wholly-owned subsidiary of Gulf Oil Corporation, is drilling its first exploration well in Turkey. The well, Murefte No. 1, is being drilled on the outskirts of the village of the same name, which is in Thrace some 168 miles west of Istanbul on the shore of the Sea of Marmara. The well is being drilled by Pergeo, an Italian drilling contracting company, with a rig which was transferred from Gulf Italias operations in Sicily, where Pergeo has drilled several wells for Gulf Italia.

COLORADO

Paradox Basin Site Of New Discovery

Phillips Petroleum Company has a new Paradox Basin oil discovery on a full-interest 2600-acre lease block in southwestern Colorado. The company also holds 4240 acres of leases five miles southeast of the well.

The wildcat, No. 2 Desert Canyon, flowed 280 bbl of 41.5-gravity oil daily through a small choke from 23 net ft of Ismay pay beginning at 5902 ft. Gas-oil ratio was 1632 to 1. The discovery is nine miles east of production in the Greater Aneth Area of the Paradox Basin where Phillips has drilled 67 oil producers and is in Section 11-34N-20W, 38 miles southeast of Blanding, Utah.

VENEZUELA

New Area Opened In Eastern Venezuela

A new producing area in the important Aguasay region of the state of Monagas, Eastern Venezuela, has been opened with completion of a successful dual-zone wildcat by Sinclair Venezuelan Oil Company. The new well, known as East Aguasay No. 2, was completed in two zones, one at 14,183 ft, the other at 14,264 ft, for a total of 1352 bbl daily of about 30-gravity crude oil.

The new producer is 3 miles east of Aguasay No. 1, Sinclair's discovery well, which is 8 miles east of the established Aguasay field. The well proves, in the company's opinion, a major continuation of the producing trend, which now extends over 10 miles of Sinclair concessions.

LIBYA

Successful Test Extends Dahra Field

Extending its Dahra field of north central Libya three miles to the southeast, Ohio Oil-Continental-Amerada group's F-2-32 exploratory well flowed at a rate of 2800 bbl per day through the casing. The 43-gravity oil came through perforations from 3086 to 3150 ft and from 3160 to 3180 ft. Total depth is 3765 ft.

Oasis Oil Company of Libya, wholly-owned subsidiary of the Ohio Oil Company, is operator of the group's Libyan acreage. Including this new extension, Oasis has drilled nine wells on Concession 32. Five of these are oil wells, two are gas, and two are dry holes.

For fishing, testing and core-drilling strings . . .

...plus Safety Joint protection!

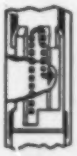
THE SHAFFER OIL-SEALED JAR SAFETY JOINT

The Shaffer Oil-Sealed Jar Safety Joint is the only tool that combines a choice of *jar-up* and *releasing* actions, both under complete control of the operator at all times. What's more, all operating parts are sealed in a chamber filled with clean oil, fully protected against mud, sand and corrosive fluids.

The sealed-in-oil protection not only safeguards against abrasion and corrosion, and minimizes pressure differentials on packing elements, but also insures constant operating characteristics at all depths. This makes the tool ideal for fishing, testing and similar strings where light connections and equipment are used!

Jar-Up Action

JARRING ACTION IS AUTOMATIC—simply raise the drill string until tension equals the pre-set tripping load, whereupon a sharp up blow is struck. Lowering the tool automatically re-sets the tripping mechanism for another blow—and repeated blows can be struck as fast as the string can be raised and lowered.



Releasing Action

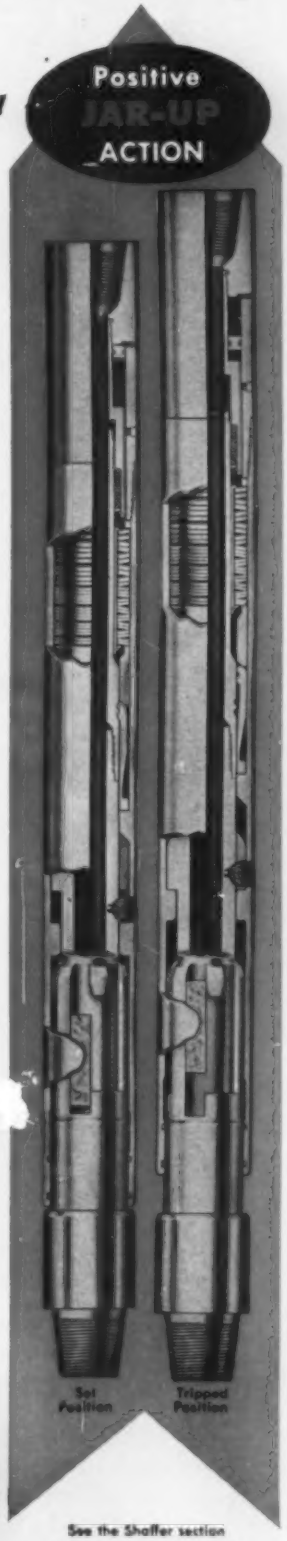
ONLY STRAIGHT PULL is necessary to operate the tool—no torque or other secondary operations to affect the light connections commonly used in fishing, testing and coring strings.

TO RELEASE, in the event the fish or stuck string cannot be loosened, simply trip the tool and apply reverse torque as the string is slowly lowered. Only one-sixth turn of the drive keys rotates them into an unlocking slot whereupon raising the string allows the parts to unlock.

AND NOTE THIS—not only does the tool transmit full torque loads in *either* direction, but no threads are used in the releasing mechanism. Therefore there's no risk of torque over-tightening the tool—nor can reverse rotation accidentally release it.

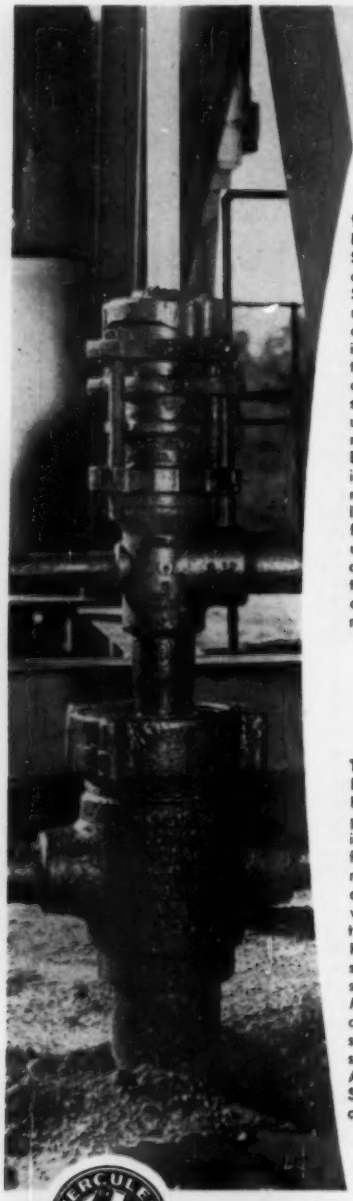
Also, force of the blow is absorbed by integral knocker heads—not by easily damaged drive keys or threads. The tool is designed for *sustained* jarring operations. And since it does not depend upon friction for its tripping action, the Jar Safety Joint always operates with the same pre-set action. Light strings are not subjected to unpredictable loads!

Free 8 page booklet gives many other facts about the Shaffer Oil-Sealed Jar Safety Joint. Write for it—or ask your nearest Shaffer representative.



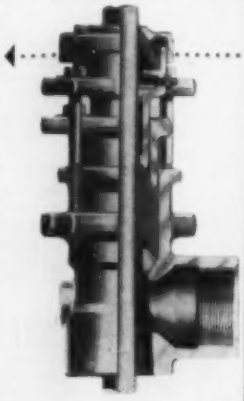
See the Shaffer section of your Composite Catalog.

HERCULES products in ACTION

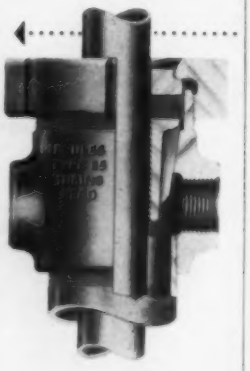


A typical set-up is shown below in Creek County, Oklahoma, using Hercules "Tee Type" Duplex Polished Rod Stuffing Box and Type "E5" Tubing Head. This is an easily assembled, effective and economical producing unit.

"TEE TYPE" DUPLEX POLISHED ROD STUFFING BOX—A combination Tee and Stuffing Box with female thread to screw directly onto the tubing, eliminating one threaded connection and resulting in a considerably shorter hook-up. With internal parts removed, the Stuffing Box body is full opening and need not be removed to pull rods. In addition to being furnished in the most used sizes, special combinations of threads and outlets can be furnished on request.



TYPE "E5" TUBING HEAD—This Tubing Head is ideal for any pumping situation. It is economical enough for shallow wells and rugged enough for any depth well, with working pressure up to 1500 pounds. Hercules self-aligning slips suspend the inner string in this Head. Mandrel suspension can be furnished instead of slips, if desired, at no extra cost. A neoprene Tubing Stripper Unit is also available.



Write for complete information on any Hercules Product.

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Exploration

NEW MEXICO

Test Will Search For Productive Zones

A Lea County prospect has been staked by Trice Production Company to test for productive zones in the Four Lakes field. The company's No. 1 Four Lakes-State of New Mexico will be drilled to a maximum depth of 13,000 ft. Its targets are the Cisco Lime at 10,000 ft, Canyon Lime at 10,200 ft, Bend Sand at 11,300 ft, and Devonian Dolomite at 12,600 ft.

The prospect is located in the center of the northeast quarter of the northwest quarter of Section 11, T12s, R34e. It is ½ mile southwest of nearest production in the Four Lakes field and two miles north of Ranger Lake field.

Lea County Discovery Tested at 1252 BOPD

Monterey Oil Company and its partners have made a new Devonian formation oil discovery in Lea County near the center of a block of 1120 acres in which the company has a 25 percent working interest. The well flowed on a 6-hour potential test at the rate of 1252 bbl per day of clean oil on a 3/8-in. choke through 20 ft of perforations at a depth of slightly more than 12,000 ft. Production of the well, known as Pure Oil-Monterey Oil-Kern County Land Co. Federal D No. 1, showed a low ratio of gas to oil. The discovery is approximately 2½ miles southwest of Crossroads field which was discovered in 1948.

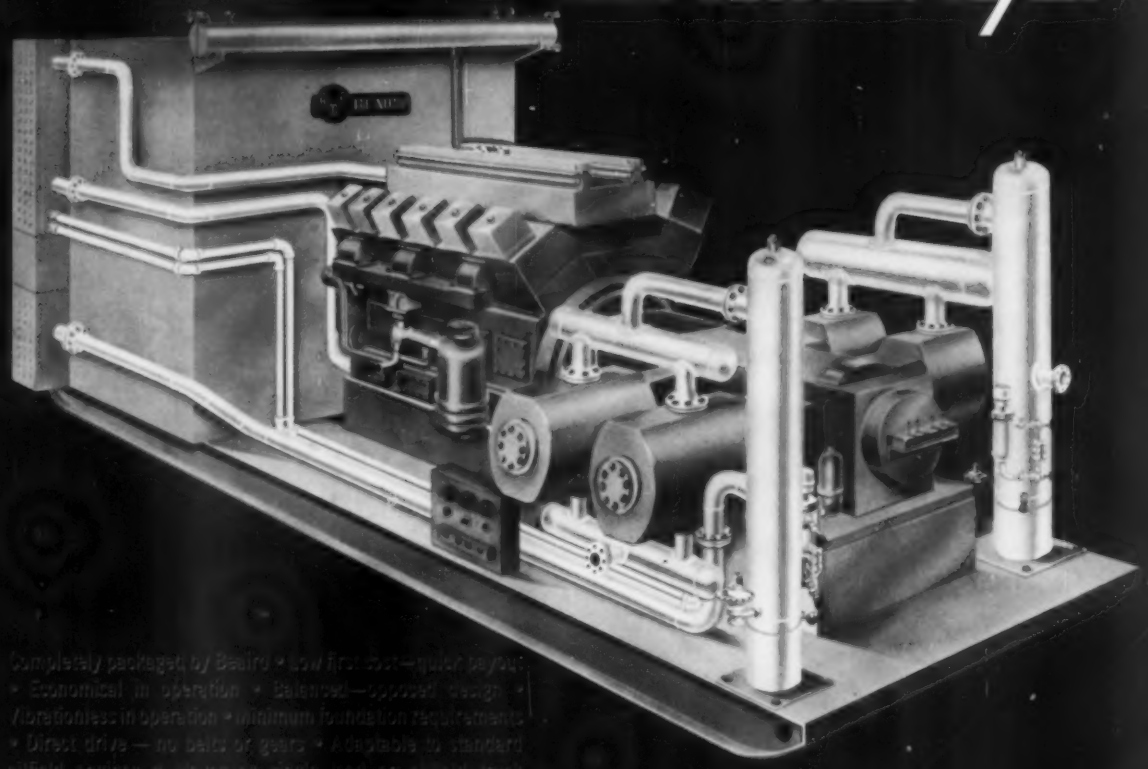
AIME, OIL SCOUTS PREPARE JOINT OIL REVIEW

A jointly-compiled volume entitled "International Oil and Gas Development in 1959" will be published in 1960 as a cooperative service of the Society of Petroleum Engineers of AIME and the International Oil Scouts Association. The joint work will supplant separate statistical volumes heretofore published annually by each.

The combined efforts of the two organizations will produce a two-part volume for 1959 which lists exploratory wells drilled throughout the world, the world's oil and gas field production figures, and all information covered in the past. The expected result is some 1400 pages of comprehensive statistical and background material on exploration, development, and production.

Governing boards of each organization predict that the combining of the publications will result in a great saving in time and effort for the various oil and gas companies which have sponsored contributors for the separate books previously.

NEW BEAIRD INGERSOLL-RAND Challenger



Completely packaged by Beaird • Low first cost—quick delivery • Economical in operation • Balanced—opposed design • Vibrationless in operation • Minimum foundation requirements • Direct drive—no belts or gears • Adaptable to standard oilfield engines • Moves as single load on oilfield truck

PACKAGED COMPRESSORS 100 TO 400 HORSEPOWER

NEW FROM BEAIRD... Economical HHE Series Packaged Compressor Plants. Gas engineered and completely packaged by Beaird, the HHE Series compressors offer new economy and flexibility of operation in a horsepower range below Beaird Ingersoll-Rand SVG compressors.

Beaird HHE Units are furnished in two and four cylinder models covering a range of 100 to 400 horsepower. They can be designed with one, two or three stages of compression.

HHE Compressors are of the balanced opposed design that provides smoothest operation and best running balance. Ideally suited to barge or piling installations, they are vibration free and can be mounted on minimum foundations. The driving engine is directly connected to the compressor by a simple block coupling. No belts or gear trains are required. Any oilfield engine of adequate horsepower can be specified by the purchaser.

Completely packaged compressor stations, Beaird HHE Units are furnished with every control, valve, scrubber, manifold and connection needed to place them into operation. The radiator includes cooling sections for engine water and oil, as well as gas interstage and after cooling, when desired. Mounted on the main skid as an integral part of the compressor package, radiators may be furnished with either horizontal or up-draft air discharge. Fully assembled on rigid skids, an HHE Packaged Compressor Plant moves as a single load on standard oilfield vehicles.

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For any secondary recovery method ...look to Gardner-Denver equipment

- Water flooding
- Gas injection
- Miscible phase
- In situ combustion
- Vacuum maintenance
- Gas slug drive

RESEARCH TAKES A LONG VIEW

At the start of our second century Gardner-Denver men are calling on the knowledge and experience of a century of progress to develop new and better ways of helping the men of industry, construction, mining and petroleum multiply productiveness and build a better world.

In oil company laboratories Gardner-Denver secondary recovery specialists work side by side with petroleum engineers to develop pilot plant equipment. On field tests Gardner-Denver men and equipment help work out practical applications.

When new secondary recovery projects get under way, equipment specifications call for Gardner-Denver. Dependable, field-proven Gardner-Denver pumps and compressors are available in a wide range of capacities and pressures. Complete packaged units are assembled, tested and shipped from our Dallas oil field plant.

Consult with Gardner-Denver specialists on any secondary recovery problem—anywhere in the world. Specify Gardner-Denver compressors and pumps with confidence. Call or write for details.

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FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

Companies With Excellent Management

FOR THE FIFTH YEAR, the American Institute of Management has published its "Manual of Excellent Managements" as one of its projects. The staff states that the list is not necessarily the best managed companies in the United States, but they are the best of some 5000 companies the staff examines, mainly by use of its management audit questionnaire.

According to the results of this study, these excellent managements in the petroleum industry are:

Amerada Petroleum Corporation
Arkansas Louisiana Gas Company
Atlantic Refining Company
Cities Service Company
Continental Oil Company
Creole Petroleum Corporation
El Paso Natural Gas Company
Equitable Gas Company
Gulf Oil Corporation
Humble Oil & Refining Company
Imperial Oil Ltd.
Lone Star Gas Company
Louisiana Land and Exploration
Monsanto Chemical Company
Northern Natural Gas Company
Northwest Natural Gas Company
Ohio Oil Company
Oklahoma Natural Gas Company
Panhandle Eastern Pipe Line Co.
Phillips Petroleum Company
Richfield Oil Corporation
Shamrock Oil and Gas Corporation
Shell Oil Company
Socony Mobil Oil Company
Standard Oil of California
Standard Oil Company (Indiana)
Standard Oil Co. (New Jersey)
Standard Oil Company (Ohio)
Sun Oil Company
Texaco, Inc.
Union Oil Co. of California

This year's fifth edition has changed the emphasis to some degree from presenting factual material to a discussion of the theory and practices of management, as exemplified by the 501 companies selected. The introduction reads:

"As the body of case material available to the Institute develops, it becomes more apparent that it may be possible to develop a 'unified field theory' of management."

The general theory developed summarizes that management is the art of:

—selecting certain ends from those available;
—making the selection with due allowance for the nature of the field of action and for the means it can be made to afford;
—resolving the chosen ends into elements achievable separately and contributing to the main ends and arranging them in plans;
—enlisting assistance by relating the ends of the enterprise to the private ends of cooperating individuals;
—creating an organization by delegating responsibility for various elements;
—supervising, controlling, and coordinating activity to obtain effectiveness with efficiency;
—minimizing unwanted effects of the means employed;
—providing for adequate internal and external communications;
—providing and husbanding the scarce resources required;
—obtaining new and additional information and ideas;
—reviewing, reassessing, and adjusting continually the ends, the means, and the performance with constant alertness to changing conditions;
—discharging moral claims and resolving moral conflicts;
—doing all this in ways consistent with realization of the larger goals of human life.

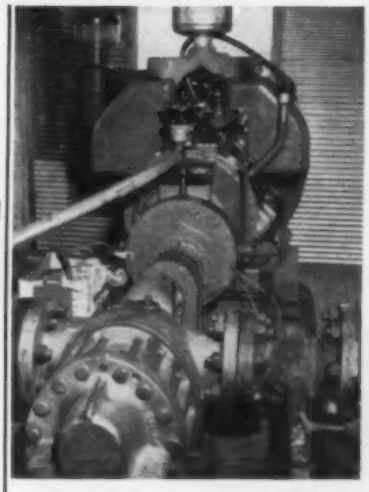
(Manual of Excellent Managements, Fifth Edition, American Institute of Management, 125 E. 38th Street, New York 16, New York. Price, $20.)

ROCKFORD

ROCKFORD Gear Reduction Assembly

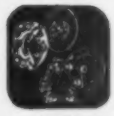
Helps Wisconsin Engines Drive Pumps, — Avoid — Shut Downs

ROCKFORD Speed Reducers incorporate a clutch, power take-off and reduction gear in one complete unit. This combination insures reliability under the most extreme conditions.



Here is one of the 56 HP Wisconsin VR4D engines powering a rotary pump in a pipeline operation near Harrisburg, Nebraska. It was 35 degrees below zero when this picture was taken and summer temperatures hit 120 degrees above zero in the "dog house" enclosure. This engine and all the other VR4D's in the system must operate continuously throughout the winter because of the quick "set-up" of the heavy crude oil. One shutdown could eliminate the discharge flow through the entire system until the next spring.

The ROCKFORD Clutch, Power Take-Off, Gear Reduction unit saves oil field operators servicing time and money.



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Speed Reducers

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Gives dimensions, capacity tables and complete specifications. Suggests typical applications.

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CLUTCHES

What's doing in DRILLING

Year-End Rig Activity Follows Annual Upswing

The historic year-end flurry of drilling activity has pushed the number of active rotary rigs in the United States and Canada toward a new high level for the year. On November 30, there were 2407 rigs busy in the two countries, the highest number since June 22 when the count was 2436 active rigs, representing peak activity for the entire year up to the November 30 survey.

On March 9, 1959, for the first time in many months, the number of active rotary rigs in the United States and Canada was up to the level registered a year previous. On that date there were 2073 rotary rigs busy in the two countries, compared with a total of 2013 active rigs recorded on March 10, 1958. The 1959 level of activity then remained higher than the corresponding 1958 level.

Electric Rig Sets New 8-Hour Drilling Record

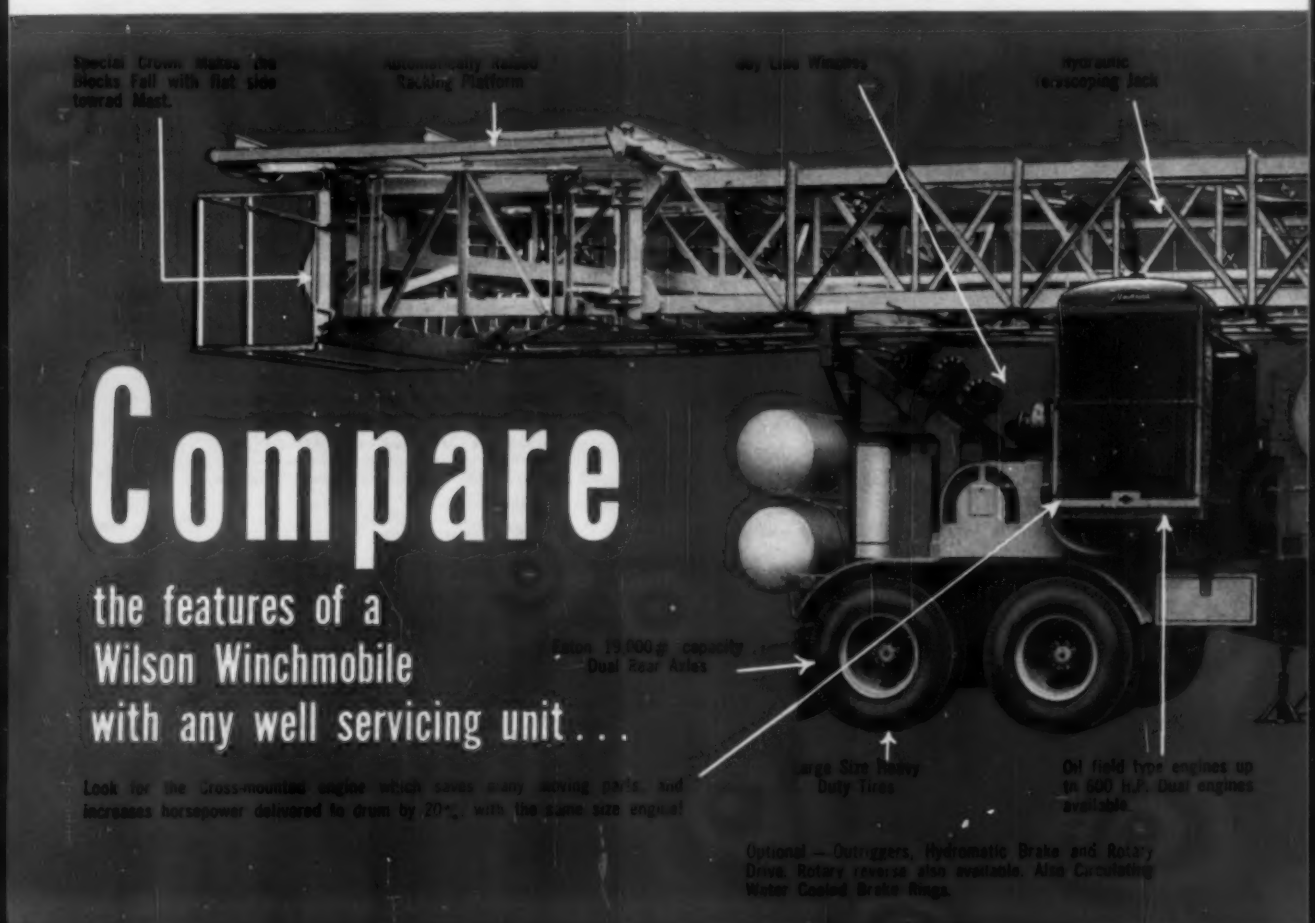
An electric drive equipped, portable drilling rig of the Mene Grande Oil Company has set what is believed to be a new drilling record for an 8-hour tour. MGO's crew drilled 9⅝-in. hole from 381 to 3840 ft — a total of 3459 ft — during the work period.

The rig drilled 204,100 ft and completed 39 wells during the first ten months of service, or an average of 7.8 days per well. Final depths range from 4441 to 6844 ft with an average of 5280 ft.

MGO's Rig 31 basically consists of two trailers. The power unit contains five 320-hp gas-butane engines with generators and the required alternating-current and direct-current exciters. The drawworks trailer consists of drawworks, transmission, drilling motor, and rotary table with 126-ft mast.

— Photo Courtesy General Electric Company.

One drilling generator is driven by each gas engine to produce d-c power for the motors, one of which drives the drawworks and the two others which operate 300-hp and 600-hp mud pumps.


Special Crown Makes the Blocks Fall with flat side toward Mast.
Automatically Raised Racking Platform
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Compare
the features of a
Wilson Winchmobile
with any well servicing unit . . .
Dual Rear Axles
Large Size Heavy Duty Tires
Oil field type engines up to 600 H.P. Dual engines available.
Optional — Outriggers, Hydromatic Brake and Rotary Drive. Rotary reverse also available. Also Circulating Water Cooled Brake Rings.

World's Safest Rig Honor to Humble

Humble Oil & Refining has claimed the honor of world's safest drilling rig for its unit No. 39. This distinction was achieved at 11 a.m. on October 28 with the completion of 566,000 man-hours of work without a single disabling injury. At that time, the rig was at work in Lake Raccourci of South Louisiana. Rig 39 has drilled 53 holes in 10 years of operation.

U. S. Judge Cautions Offshore Drillers

A United States federal judge warned offshore oil operators not to put their faith completely in the law to protect their insurance contracts. The law may be undependable, John R. Brown, circuit judge of the United State Court of Appeals, fifth circuit, Houston, told participants at the Tulane University Mineral and Tidelands law conference recently in New Orleans. He emphasized that it is often difficult for a court to interpret insurance contracts properly which are written in a "conglomerate jargon irresponsibly put together at random."

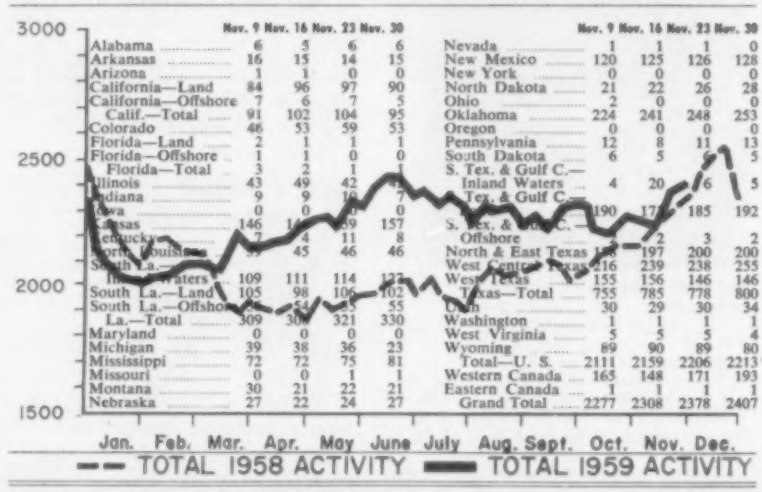
"The only way in which offshore operators can protect themselves fully against a court interpretation of an insurance contract — which could ruin their business — is to arm themselves with a competent force of genuine experts: admiralty lawyers, insurance consultants, brokers, and marine underwriters," Judge Brown emphasized.

Referring to special hazards of mobile rigs, the jurist pointed out that capsizing is the most common loss. "Almost all insurance policies contain a clause stating that the insurer is not liable if capsizing is the result of an error in design," he stressed. What is to be the standard of comparative references in determining whether the error was in design? This is often an unanswerable question because courts have no basis on which to compare the seaworthiness of crafts with such unique purposes, he said.

Rotary Rigs Operating in Oil Fields of United States and Canada

As reported to American Association of Oil Well Drilling Contractors by Hughes Tool Company.

	Nov. 9	Nov. 16	Nov. 23	Nov. 30
Alabama	6	5	6	6
Arkansas	16	15	14	15
Arizona	1	1	0	0
California—Land	84	96	97	90
California—Offshore	7	6	7	5
Calif.—Total	91	102	104	95
Colorado	46	53	59	53
Florida—Land	2	1	1	1
Florida—Offshore	1	1	0	0
Florida—Total	3	2	1	1
Illinois	43	49	42	43
Indiana	9	9	10	7
Iowa	0	0	0	0
Kansas	146	149	159	157
Kentucky	4	4	11	8
North Louisiana	39	45	46	46
South La. Inland Waters	109	111	114	127
South La.—Land	105	98	106	102
South La.—Offshore	95	99	101	101
La.—Total	309	308	321	330
Maryland	0	0	0	0
Michigan	39	38	36	23
Mississippi	72	72	75	81
Missouri	0	0	1	1
Montana	30	21	22	21
Nebraska	27	22	24	27
Nevada	1	1	1	0
New Mexico	120	125	126	128
New York	0	0	0	0
North Dakota	21	22	26	28
Ohio	2	0	0	0
Oklahoma	224	241	248	253
Oregon	0	0	0	0
Pennsylvania	12	8	11	13
South Dakota	6	5	6	5
S. Tex. & Gulf C.—Inland Waters	4	20	16	5
Tex. & Gulf C.—Land	190	172	185	192
S. Tex. & Gulf C.—Offshore	1	2	3	2
North & East Texas	198	197	200	200
West Central Texas	216	239	238	255
West Texas	155	156	146	146
Texas—Total	755	785	778	800
Utah	30	29	30	34
Washington	1	1	1	1
West Virginia	5	5	5	4
Wyoming	89	90	89	80
Total—U. S.	2111	2159	2206	2213
Western Canada	165	148	171	193
Eastern Canada	1	1	1	1
Grand Total	2277	2308	2378	2407



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Air Controls of choice of three positions
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Kick-over Jacks
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Winch Drive does not go through Bevel Gear or Universal Joints. 4 Speeds and reverse drive to rear Axle.
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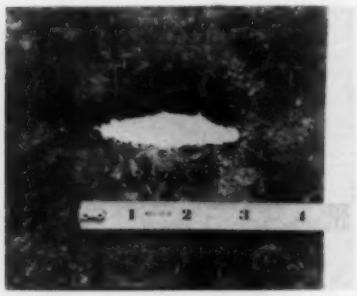
It's New

Drilling – Producing Equipment

Special Jet Guns

Four types of new special purpose jet guns and charges are now offered by Pan Geo Atlas. These are recent additions to the company's complete line of steel-case



retrievable guns and expendable tubing-type guns.

The slot-jet perforator produces a hole through the casing approximately ½-in. wide and 3-in. long.

The perforator is an expendable, exposed-type charge containing 72 grams of explosive. It assembles into a gun of 3¾-in. OD and may be fired at 1, 2, or 3 shots per ft.

Two new types of fracture placement or fracture initiating charges also are now offered by PGAC. These charges are designed primarily to provide a large number of perforations on a single horizontal plane to initiate fracturing along that plane. One type, the Frac-Jet, provides eight shots at 45 deg on a single plane. The other type, the Fracture Initiating Charge, provides six parallel perforations, three in each direction on a single plane. Both types are available in diameters for 5-in., 5½-in., and 7-in. casings.

The strip jet perforator has 1 11/16-in. expendable-type swing jet charges mounted in a steel strip carrier. After the gun is fired, the carrier itself is withdrawn from the well. It can be assembled in gun diameters of 3¼-in. or 3-in. OD, with 1 to 4 shots per ft, and gun lengths up to 100 ft may be used on one run in the well. *Pan Geo Atlas Corporation.*

Circle number (1) on reply card.

Dry Chemical Fire Fighting Unit

A new fire fighting unit applies a large amount of dry chemicals on oil field fires. It discharges larger amounts of dry chemicals than units previously available.

Two types, the skid-mounted "FIRE-PAC," and the truck-mounted "FIRE-BOSS," are available.

Tests held recently in Houston, Texas, demonstrated to a group of oil executives operation of the unit in fighting oil and gas fires. *Fire Control Engineering Company.*

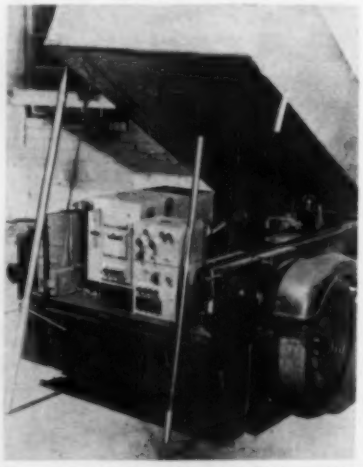
Circle number (2) on reply card.

Caliper Added To Logging Instrument

A caliper attachment has been added to the Geo-Logger. The attachment can be opened or closed at will for quick information on hole size variation at any point of hole penetration.

Applications cover determination of packer seat location, formation correlation, location of cavities, and finding different casing pipe sizes on old wells.

Two arm sizes for the caliper attachment are available. One is from 2 in. to 18 in., and the other is from 2 in. to 36 in. Speed of logging is 50 ft per min.



The compact unit is portable, being mounted on a trailer for transportation to the well site. *Well Reconnaissance, Inc.*

Circle number (3) on reply card.

Kelly Extension Drive

Drilling & Service has added the Kelly Extension Drive rental to their current line of rig side services tools.

The extension is designed for use during diamond coring, fishing, washover, spudding in, drilling back through a keyseat or tight hole with full circulation, through cored interval with full circulation, and drilling under pressure.

Advantages claimed by the company are that it minimizes connections, is easily installed and removed at any stage of operations without interrupting full circulation, operates above rotary table, no moving parts or packing down-hole to invite trouble, accomplishes the same purpose as power swivel and power unit at much less cost, API dimensions, top and bottom, therefore will fit any size or type Kelly without alterations to rig equipment; sturdy and safe in operation to both rig and personnel.

The drive is especially adaptable to diamond coring, the company states, since it eliminates the necessity for connections and interrupting continuous circulation during an entire 50-ft core interval. This prevents junk iron, pieces of formation, or both from falling under the bit to cause damage.

The extension drive is available in two sizes, 30 ft, 2200 lb; and 20 ft, 1750 lb. *Drilling & Service, Inc.*

Circle number (4) on reply card.

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Field Tested and Approved
150 psi working pressure

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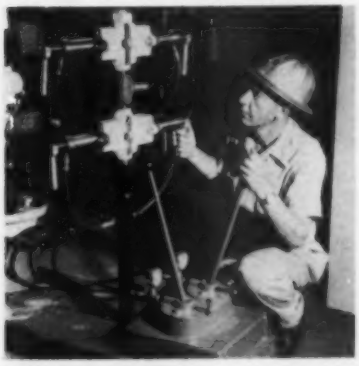
VALVES

New Equipment

Hydraulic Oil Saver Has Manual Take-over

A newly-developed hydraulic oil saver, first to feature a built-in capacity for immediate manual takeover in event of hydraulic failure, has been unveiled by Skinner Brothers.

The hydraulic application can be incorporated into conventional oil savers, both sand line and drilling line types.



With the equipment, wire line stripping operations can be conducted from below at a levered pump box without sending a man up the rig to perform the function manually.

The manual takeover feature requires no adjustments, and can be put into effect immediately in the event of trouble in the hydraulic system.

The hydraulic pump box can be mounted in virtually any position, horizontally or vertically.

Wire line strippers are mounted in tandem, with a hook-up for an individual pump for each stripper at the common base. *Skinner Brothers Company.*

Circle number (5) on reply card.

Gas Line Heater

The Merla Type M-3 Gas Line Heater features indirect action whereby a gas burner heats a bed of aluminum pellets which radiate even, all-over heat to the heavy-wall steel gas tube.

There's no water to boil away, and an insulated jacket is easily dismantled for inspection. It has an automatic gas shut-off since both maximum and minimum temperature controls are standard equipment on the heater, which is also a safety feature.

The unit is constructed soundly, and is heavily insulated for efficiency. It has a two-stage fuel regulator, and a filter drip pot. *Merla Tool Corporation.*

Circle number (6) on reply card.

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AERO HUNTS OIL DOWN UNDER

New Australian airborne magnetometer survey for Magellan Petroleum Corporation will cover 30,000 square miles

Map shows 30,000 square mile area in Australia being surveyed by Aero Service Corporation for Magellan Petroleum Corporation.

Operating from two bases in Queensland – Charleville in the north and Longreach in the south –Aero Service crews are at work right now mapping petroleum concessions in a 30,000 square mile area of north central Queensland. The survey is being performed for Magellan Petroleum Corporation.

The high sensitivity Gulf airborne magnetometer, Mark III–a proved reconnaissance tool–is being used to determine the thickness of sedimentary sections of the area. An Aero spokesman explained that the instrument would also point out areas of unusual interest where anticlinal structures may be present.

The survey is being flown at an altitude of 2,000 feet. Flight lines are spaced at 3 miles, in an east-west direction. Magnetic data are being compiled at a 10 gamma interval, on maps at a scale of 1 inch = 2 miles. First maps are scheduled to be delivered by Aero Service crews about 45 days after completion of the survey.

Aero's DC-3 (above) is shown with Gulf high-sensitivity Mark III magnetometer trailing from aircraft.

This aerial survey represents Aero's second major surveying job in Australia. A few years ago Aero crews made an aerial survey of over 80,000 miles of Australian desert.

Aero experience is world-wide: from Alaska to the Spanish Sahara, Aero crews are carrying out airborne geophysical studies. Aero representatives will be glad to provide complete information on the experience and capabilities of the company. Crews are ready to undertake new assignment anywhere in the world. Find out how these "on location" crews can cut mobilization costs.

Aero Service's fully integrated mapping services include airborne magnetometer surveys, geophysical interpretation, aerial photography, photo interpretation, photo mosaics, pipe line surveys, relief models and topographic plans. It employs the Gulf magnetometer and RADAN,® Shoran, Lorac, Raydist and Decca plane-positioning systems.

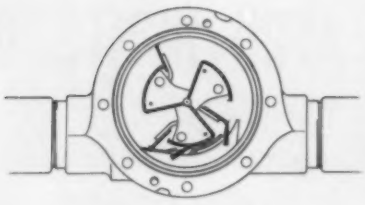
Aero's representative in Australia is M. H. Lawrence, P. O. Box 6, Hurstville, New South Wales. In Europe and North Africa, W. P. Des Laurier at Avenida America 2-11-B, Madrid, Spain, is Aero's representative. World headquarters of Aero Service Corporation are located at 210 East Courtland St., Philadelphia 20, Pa., U.S.A.

New Equipment

Positive Displacement, Rotary-Type Meter

Floco Meter, a positive displacement rotary type, is designed to meter fluids accurately with a minimum of attention and maintenance.

The meter has only one part, which is actuated by only the fluid flow; a rotor with flexible blades compressed by a positive displacement stationary cam; balanced rotor design with rotation always in the same direction, without metal to metal contact, reduces friction, minimizes wear, resists corrosion, and operates with low pressure drop and sustained accuracy, the manufacturer states.



The meter measures the fluid passing through it by separating the fluid into segments and counting them. It carries through the measuring element a fixed quantity of fluid for each revolution of the rotor and registers this quantity on a register.

Fluid enters through the inlet port of the meter and strikes the bridge. This diverts the fluid downward, striking one of the rotor blades and turning the rotor. This action applies the principle of the rotor dividing the fluid into segments and counting them.

The fluid passes out of the meter at the outlet port, which is in direct line with the inlet port. This feature allows foreign particles and sediment to pass through the meter without causing damage or malfunction.

The bridge rubbers on the bridge prevent any of the fluid from passing to the outlet side of the meter without being measured. *Flow Equipment Company, Inc.*

Circle number (8) on reply card.

Tight Seal
ASSURED
in
Hardy-Griffin
GT-API Modified
Couplings
Leak-tight coupling joints are assured and no joint strength is lost with the GT-API modification in the Hardy-Griffin Teflon* sealed couplings.
While recommended for all API tubing and casing applications, the GT seal is particularly valuable where high pressure or resurgent shock is a problem.
For tight seals in either couplings or integral joints, look to Hardy-Griffin.
H-G — New Leader in Tubing Joint Engineering for High Pressure and Maximum Clearance Connections
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ENGINEERING CORPORATION
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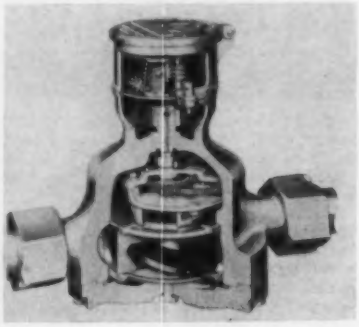
*DuPont's Tetrafluoroethylene Resin

Water Flood Meter

A high pressure water meter, designed for use where oil is produced by water flooding, has been introduced by Rockwell.



Operating on the nutating disc principle of positive liquid displacement, the new Model 504 "Five Pointer" has a maximum capacity of 20 gpm or 30 bph.

The meter is pressure rated at 2000 psi and pressure tested to 4000 psi for rugged performance in measuring water consumed at each flooding point. It has 1¼ in. straight male threads with swivel connections for ½-in., ¾-in., or 1-in. standard pipe.

The unit of registration is a straight reading, non-reset register in gal or bbl with a totalizer capacity of 5 digits. *Rockwell Manufacturing Company.*

Circle number (9) on reply card.

New Process Combines Seismometer Traces

A new process for mapping stratigraphic formations by integrating the data from all 24 seismometer groups of a seismic spread into a single trace has been reported by Western Geophysical Company. The process, still in experimental stages, is based on conventional static and dynamic corrections followed by the integration of a predetermined function of wave energy over the space covered by the seismometer spread and through a short period of record time. The result is a record resembling an electric well log. The apparatus, known as Summarizer, produces an output with an unusual amount of 'character' by suppressing noise by summation and integration rather than sharp filtering. *Western Geophysical Company.*

Circle number (10) on reply card.

New Literature

Hose and Fittings Bulletin in Spanish

A new bulletin printed in Spanish on Stratoflex hose and fittings for all types of industrial applications is now being offered by Stratoflex, Inc.

This brochure contains a complete description of the products including pictures and charts showing design features of the assemblies. Specifications, dimensions, and construction of the hose and fittings are aptly described.

The same bulletin will soon be available in French. *Stratoflex, Inc.*

Circle number (11) on reply card.

Eliminating Explosions In Compressor Air Lines

New Bulletin 173 presents latest findings on the mechanism of explosions in pipelines and compressor starting air lines.

Authored by Robert S. Ridgway, Standard Oil of California, the article discusses research on the nature of explosions and shock waves in piping. These observations are then applied to compressor air starting systems providing a more thorough understanding of the origin of explosions and the propagation of shock waves within the piping.

The study concludes with a discussion of preventive measures that can be taken to eliminate explosions in air starting systems. *Clark Bros. Co.*

Circle number (12) on reply card.

Casinghead Data

Casing heads for suspending up to 295,000 lb of casing in wells of 2000 psi working pressure are presented in Bulletin No. 498 by National Supply. Bulletin illustrates the Type G casing head, its "full-opening" through bores, demountable flanged adapters for preventer installation, and male thread adapters for tubing head installation. It covers 2 nominal sizes providing a total of 5 bores for outer string sizes of 7 to 10¾ in. *The National Supply Company.*

Circle number (13) on reply card.

Flexible Couplings

An expanded line of Dodge Para-flex flexible cushion couplings ranging from fractional to 190 hp per 100 rpm is described in a new 12-page bulletin, No. A669C.

Two new sizes have been added to the 10 previously offered to increase the scope of industrial applications for which the coupling can be used. New PX24, largest in the line, is capable of delivering up to 2000 hp at 1080 rpm. This is 2½ times the maximum hp of the largest coupling previously offered. Photographs, drawings and text explain design features and operating characteristics of Para-flex.

Introduced in the United States only two years ago, the rubber-tire coupling accommodates angular misalignment, parallel misalignment and end float—singly or in any combination. It also cushions shock loads and diminishes torsional vibration.

Detailed tables of horsepower ratings, prices, dimensions, and service factors for many applications are included to make selection easy. *Dodge Manufacturing Corporation.*

Circle number (14) on reply card.

Oil Field Catalog

Kerotest Manufacturing Company has released a new catalog containing pertinent data on oil and gas field drilling and production valves, fittings, well control equipment and accessories.

The 16-page bound and punched catalog is coded KS-1-P. *Kerotest Manufacturing Company.*

Circle number (15) on reply card.

Precision Test Gage

Illustrated literature describing the new and improved Martin-Decker precision test gage is now available.

Bulletin M-28A includes accuracy and sensitivity specifications, dial graduation reproductions of available capacities, finish specifications, models available, mounting dimensions and drawings.

The bulletin shows a full size reproduction of the test gage to illustrate the more than 100 sq in. of panel space saved.

Features of the gage are: Precise readings, full 360 deg; accurately calibrated from zero to capacity (15% full scale anywhere on dial); movement calibrated to dial; balanced gage pointer with 90 deg turned tip for fine reading; mirror-finish under pointer tip minimizes parallax error; tube tip bleed for flushing and purging is standard equipment; and Ni-Span C Bourdon tube corrects temperature effect.

The gage is available in capacities from 60 psi to 15,000 psi. *Martin-Decker Corporation.*

Circle number (16) on reply card.

MERLA'S SNAP-ACTION

WFM-3

PILOT-OPERATED GAS LIFT VALVE

- Mounts on 2-1/16" OD tubing for duals in 5½" casing
- ¾", 1" and 1¼" concave mandrels available for using the WFM-3 inside 2" and 2½" casing
- Not affected by well temperatures
- Large (7/16") main valve port
- Operating spread controlled by pilot seat size
- May be controlled with surface choke

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New Literature

Data on Surfactants

A new 44-page booklet, describing the properties and uses of Tergitol surfactants, has been published by Union Carbide Chemicals.

The booklet contains extensive data for eight nonionic and four anionic surfactants, including selection, solubilities, properties, formulations, applications, performances, specifications and test methods, shipping, bulk storage, and physiological properties. A detailed bibliography and reference section is included.

Both types of surfactants give rapid wetting and penetrating action, but under different conditions. The nonionic surface active agents are of the polyethylene glycol-ether type, while the anionic surface active agents are basically sodium salts.

Surface active agents are used as well treating agents. *Union Carbide Chemicals Company, division of Union Carbide Corporation.*

Circle number (17) on reply card.

Power Take-offs

Power take-offs for oil field independent power units and built-in engines are described in a new bulletin "Power Take-offs and Gear Reduction Units."

They are available with heavy-duty over-center clutches, and they are built in a wide range of sizes to fit standard SAE flywheel housings. Shaft sizes, types of bearings, and other features are available to meet capacity, dimension and other operating requirements.

The bulletin also describes spring-loaded clutches, multiple disk clutches, and gear reduction units. *Rockford Clutch Division, Borg-Warner.*

Circle number (18) on reply card

INCREASE PRODUCTION

CLEAN OUT CHOKING SAND

Excessive sand and sediment holds back your oil. For fast, easy cleanout with fewer round trips and less downtime, use world famous Miller Sand Pumps.

Write for descriptive price list.

SAND PUMP SIZES IN STOCK

O.D.—2½, 3, 3½, 4¼, 5, 5½, 7 in. Lengths, 20, 25, 30 ft.

Composite Catalog Page 3400

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TANKS - TREATERS
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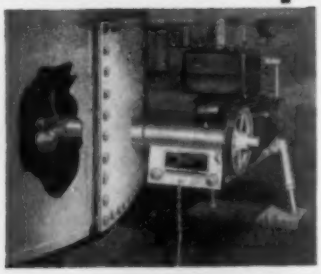
Steel Fabrication
for the Oil Industry

Now you can get rid of all your BS* at a profit!



NEW Wichita-Smith Tank Agitator makes pipeline oil out of your tank bottoms and saves you money!

This new tank agitator blends *basic sediment and chemicals quickly and thoroughly . . . settles water and results in up grading oil. The Wichita Propeller Unit is easily welded into position in lower half of manhole plate. One Wichita Power Unit can service any number of tanks. Often eliminates high priced heaters and treaters. Contact your local supply store or . . .

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NOW a UNIVERSAL TREATING COMPOUND!

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D-7 DEMULSIFIER

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1. UNIVERSAL TREATING COMPOUND . . . successfully treated different types of emulsified conditions in all areas tested.
2. TREATING TEMPERATURES REDUCED . . . reduces vapor loses, conserves gravity. More oil can be sold at better price.
3. CLEANER OIL . . . tank bottoms minimized . . . most cases eliminated!
4. CONTROL OF PARAFFIN AND EMULSION CONDITIONS . . . by mixing BRAKESOL D-7 and PARAFFIN TREATING CHEMICAL.

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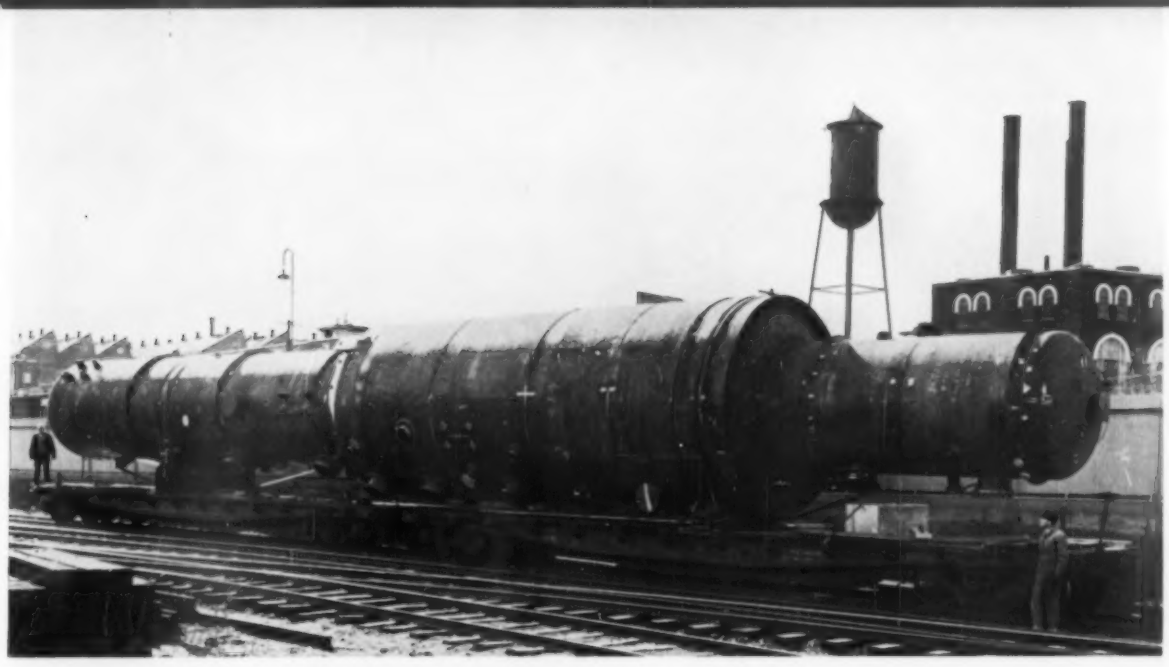

VERSATILITY

SOLVES PROBLEMS IN SHIPPING PROCEDURE

The variety of large-size work which Sun Ship's shops produce is matched by a variety of equally important shipping problems. Sun's facilities for shipping by water (overseas, coastal, or inland)—directly from our plant, are often the most economical available, and when large pressure vessels, such as those shown here, are scheduled for overseas shipment, direct, plant-to-ship loading saves additional time and expense.

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How to handle TEL susceptibility in linear programming of gasoline blending studies

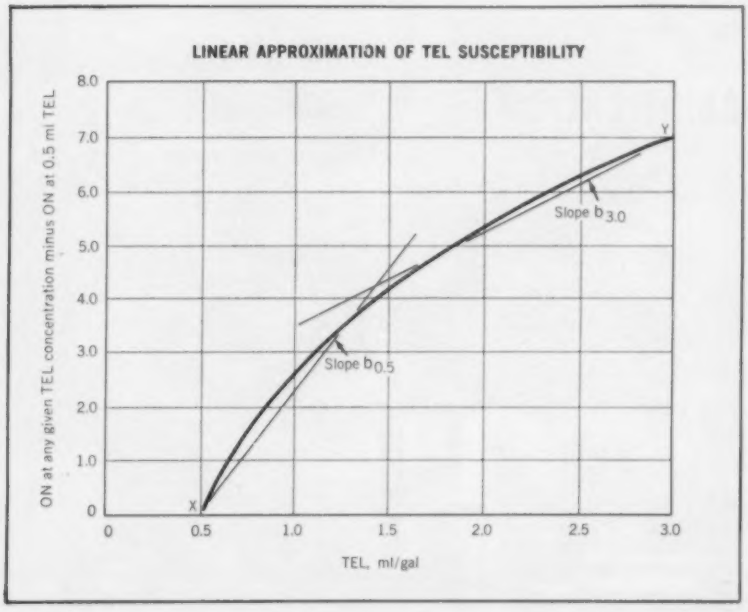
By Dr. W. C. Healy, Jr., Supervisor of the Mathematical Analysis Section,
Refinery Technology Division, Ethyl Research Laboratories

In past years, gasoline blending was comparatively simple. An engineer could establish optimum blends for two grades of gasoline by using a slide rule and a TEL response chart.

Today gasoline blending and establishing maximum antiknock effectiveness are much more complex. Many components are used to make numerous grades of gasoline. Often, market conditions divert some gasoline component to another product. All this presents the refiner with a giant-sized problem of blending for maximum profit.

The magnitude of the problem has forced the refiner to electronic computer solutions, using such techniques as linear programming.

Because TEL susceptibility is a non-linear function, it presents a special problem for computer studies when linear programming is used. Many suggestions have been made for handling the TEL function, and one of the simplest recorded to date is outlined here.



The Ethyl method of handling the TEL function is similar to others in that a target TEL susceptibility curve is approximated by straight-line segments having fixed slopes. However, it is easier to use because—

A. No extra variables are introduced.

B. No extra upper-bounding conditions are required.

C. Set-up time is reduced.

Calculating TEL linear approximations is not difficult when final blend TEL susceptibility* is known. It becomes difficult when susceptibility is to be determined by computer. Calculations must employ approximated susceptibility values while retaining accuracy for reasonable deviations.

*TEL susceptibility is here defined as the difference between octane numbers at 3.0 ml. TEL/gallon and at 0.5 ml. TEL/gallon.

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Here's How Ethyl's Method Works

For example, in the figure, two line segments are used to approximate the curve. The procedure is as follows:

A. Estimate a blend TEL susceptibility curve and then plot on rectangular coordinate paper.

B. Draw two approximating lines so that one line passes through point X (0.5, ON at 0.5) and the other line passes through Y (3.0, ON at 3.0).

C. Determine the slopes of these approximating lines, $b_{0.5}$ and $b_{3.0}$, as shown on the accompanying chart.

Then the following inequalities are required; they state that the ml. TEL per gallon shall be no less than that required on either line segment, and no greater than 3.0.

1. $\text{TEL} \geq \dfrac{\text{ON (specification)} - \text{(ON at 0.5)}}{b_{0.5}} + 0.5$

2. $\text{TEL} \geq \dfrac{\text{ON (specification)} - \text{(ON at 3.0)}}{b_{3.0}} + 3.0$

3. $\text{TEL} \leq 3.0$

Let

$X_1, X_2 \cdots X_n$ = Barrels of each component in the blend.

ON_i at 0.5 = Corresponding octane blending values at 0.5 ml. TEL/gal.

ON_i at 3.0 = Corresponding octane blending values at 3.0 ml. TEL/gal.

And $Y = (\text{TEL})(\Sigma X_i)$

Then substitute in 1 and 2 above

$$\text{ON at } 0.5 = \frac{\Sigma X_i\,(ON_i \text{ at } 0.5)}{\Sigma X_i}$$

$$\text{ON at } 3.0 = \frac{\Sigma X_i\,(ON_i \text{ at } 3.0)}{\Sigma X_i}$$

and multiply 3 by ΣX_i

These inequalities then reduce to the required linear expressions:

4. $\Sigma X_i\,(\text{ON spec} - ON_i \text{ at } 0.5 + 0.5\,b_{0.5}) - b_{0.5}\,Y \leq 0$

5. $\Sigma X_i\,(\text{ON spec} - ON_i \text{ at } 3.0 + 3.0\,b_{3.0}) - b_{3.0}\,Y \leq 0$

6. $Y - 3.0\,\Sigma X_i \leq 0$

Under certain conditions the number of inequalities may be reduced to two.

Susceptibility Changes Are Compensated

Error-compensation is a built-in feature with this method since, when blend susceptibility varies (higher or lower) from the estimated value, the line segments adjust themselves to the proper portion of the new curve.

For greater accuracy, more than two line segments may be used to approximate the susceptibility curve. This requires additional analogous inequalities, but no additional variables.

Each additional octane specification calls for an estimated susceptibility curve and the statement of inequalities as shown above.

Checking the Program Before the Computer Run.

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Special issue Editor

Impact of Computers . . . A Problem in Guidance

Harry W. Brough
Shell Chemical Corporation, New York City

IN THIS SPECIAL ISSUE we attempt to give a "panoramic" view of the impact of computers on our industry. To do it, we offer a group of papers, each illustrating this impact in a separate area of specialization. These areas are:

- Statistical Services to Research and Development,
- Technical Calculations,
- Optimization of Process Design,
- Integrated Data Processing — Business Type,
- Computer Control of Process Operations — Automation,
- Economic Optimization of Operations.

The selection of these six areas is admittedly somewhat arbitrary. However, throughout the industry there has been a tendency for followers of these specialties to drift into rather separate groups and organizations, and a real "separateness" does exist in many cases. Thus, it is perhaps not too great an oversimplification to say that each area, each group of specialists, has displayed an early growth rate and has evolved its short-term objectives largely independent of the others. The guidance required for each, though certainly substantial, has been largely within relatively local areas of activity. It has not been easy — evaluating progress, justifying expenses, acquiring the needed machines and people, and trying to find a sense of direction in the face of a sometimes explosive growth.

But as each of the local centers of computing activity acquires a measure of maturity, a new kind of managerial problem is beginning to become evident. This problem basically is one of maintaining a proper balance between the rates of development in these "separate" areas. Careful inspection of the articles included here, seems to lead to the inescapable conclusion that these specialties cannot for long be considered separate.

For illustration, let us examine the course by which a new process discovery might be developed into an operating plant if all of these specialties were fully utilized.

At the process development stage, statistical services substantially assist the laboratory and the pilot plant workers, in developing a better fundamental understanding of the process mechanism. As the project moves next into the design stage, the technical calculation specialists assist the designers with performance calculations on heat exchangers, columns, reactors and reaction kinetics. The better understanding of the mechanisms noted above enhances the effectiveness of these technical calculations. Also, we find optimizations of the design of process units, and perhaps even the entire plant, may be systematically computed on larger computers. In essence, these design optimization calculations consist of tying together the advanced design calculation methods, the technical and statistical calculations of the process mechanisms, and cost estimating in a computation scheme which systematically seeks the best combination of design choices.

After construction, management faces the start-up operation. The operators need to learn, *fast*, how this plant behaves. A data-logging system, portable or fixed, should be an invaluable aid to them in getting accurate and complete information. Meanwhile plant staff will be starting to pull together an integrated data processing system. The yield and inventory accounting portions of this system will be more economical and effective if a data-logging system has been provided, for it provides direct common-language availability of most of the data needed.

As operations stabilize, a production scheduling technique would be formalized, and should be based on a mathematical optimization.

In developing this scheduling model, real savings should accrue from proper use of computational methods developed for the design optimization. The data available from an integrated data processing system tied in with process data-logging will also aid the development, use, and continuing refinement of the scheduling model.

Assuming that automatic computed control of processing has been incorporated into our hypothetical plant, another inter-dependence of the "separate" specialties should here become evident. The computer control system operates on a short-term basis, controlling and stabilizing process operations by direct physical control. However, the set points of control are arrived at by overall economics, as treated by the production scheduling model. Before long we shall have to start treating the process control system, the production scheduling model, and the IDP system which ties them together as a single system, and guide developments in each area toward common goals.

This completes my hypothetical sketch. I believe that the elements making up this sketch are all technically possible, and in fact are all separately in use. Administratively, however, this sketch is still a forecast, and the point emphasized throughout is the way in which the benefits to be realized from these "separate specialties" will prove to depend upon the availability of the other specialties. Here then, is the challenge: To so guide the acquisition of people and machines and through them the rates of development of each of these specialties so that each is capable of contributing its share to the total development at the time that it is needed. ★ ★ ★

Mr. Brough received his BS in electrical engineering from the California Institute of Technology in 1945. In 1946, he returned to the California Institute of Technology and obtained a degree in chemical engineering in 1950 (a six year degree). He is a member of Tau Beta Pi and Sigma Xi.

After graduation in 1950, he went to work as a Technologist with Shell Chemical Corporation's Torrance butadiene plant in California, where he did pioneering work in optimizing operations and performing statistical analysis of plant operating data. Throughout Mr. Brough's professional career he has been associated with Shell Chemical Corporation, with the exception of a period from 1951 to 1953, when he was on active Naval duty as an Electronics and CIC Officer.

In addition to his work with Shell Chemical Corporation at their Torrance butadiene plant, he has been assigned to various company activities in the head office in New York and Houston, Texas, plant. At both locations he has participated in pioneering work in operations research. Presently he is on a temporary assignment at Shell Development Research Center, Emeryville, California, for advanced mathematical training and project work in operations research.

Mr. Brough has published papers on digital and analog computer problems, and participated as a panel member in computer conferences. This, coupled with his experience with Shell, has enabled him to serve as a Special Editor for REFINING ENGINEER very effectively. In this capacity Mr. Brough was instrumental in planning the contents, securing the articles, and giving technical assistance on the presentation of this entire issue. For this able assistance REFINING ENGINEER wishes to extend to Mr. Brough their very sincere thanks.

The Computer Approach to . . .

Optimizing Plant Design

Process and economic objectives brought closer together faster and with less effort by application of electronic methods

A. M. Peiser **M. M. Kessler**

The M. W. Kellogg Company, New York City

IN PLANNING the design of a process unit, two objectives should be kept in mind: (1) the **process** objective — to produce the required products from the specified feed, and (2) the **economic** objective — to minimize some suitable combination of capital investment and operating costs. The "optimum" design of the unit is the one that satisfies both the process and the economic objectives.

In actual practice, it is not necessary to find the mathematically exact optimum design although such a design does indeed exist. In the majority of cases, the economics of plant design is relatively insensitive to broad changes in the selection of operating variables. As a result, a design with operating variables quite different from the exact optimum can still yield a plant that is not far from the economic objective. It is usually difficult to justify the large effort that would be required for a small percentage gain in the overall cost. Nevertheless, when planning the design of multi-million dollar projects, a small percentage gain amounts to a considerable sum. Conscientious plant planners therefore will always aspire to inch a little closer to the summit.

The development of modern high-speed computing machinery may be expected to lead to major changes in the approach to optimum design. By reducing the tremendous computational burden which up to now has been the major stumbling block, the computer opens up untold possibilities for fruitful attacks upon the problem. How computers will be used in work of this sort may well be one of the most fascinating stories of engineering progress in this century.

How can the computer help in improving process design? Surely the possibility of using a computer to design the optimum plant in a completely "push-button" manner, is only of academic interest. In order to accomplish this, the engineer presumably would need only to specify feed, products, and economic limitations, and one command, "Start!". The machine would then select the flow pattern, the operating conditions, material balances and the equipment. The likelihood that this approach can be realized is small.

A more realistic approach would be for the engineer to select the flow pattern and the machine to "sub-optimize" as required. It would be called upon to find the operating conditions which best meet the economic objective within the framework of the flowsheet specified. There is a real possibility that this can be done. With the flowsheet fixed, the optimization problem can be stated in explicit but complicated mathematical terms. Modern developments in optimization techniques (linear programming, dynamic programming, etc.) will provide the means to optimal results.

What compromise can be made to make computers an effective tool for plant optimization today or in the reasonably near future? We must clearly seek a suitable balance between man and machine that takes advantage of the best features of both. Let the engineer select his flow scheme. Let him, through his experience and engineering judgment, select reasonable operating conditions. At this point, the computer can take over and calculate complete evaluations including all process designs, mechanical designs and costs for the entire unit. On the basis of such information the engineer can modify his conditions or even his scheme, redesign by computer, modify once more and, through a series of steps, close in on his objective.

The principle of this approach is simple and straightforward but there are serious implications in it that go to the very core of computer use. Since the engineer is limited by time, he cannot be held back by the needs of computer program development. If the program he requires takes too long to develop, it will be of no value to him. On the other hand, the engineer's freedom and imagination should not be limited by restraints of some pre-planned computer program that forces his thinking into narrow channels. The computer program must be put together **as the designer needs it** and according to the **unique requirements** of the job. We find, in the problem of plant design by computers, an excellent example of the need for the most modern of computer programming concepts, the automatic translators, compilers, and assemblers.

REQUIREMENTS OF INTEGRATED FLOW SHEET CALCULATION PROGRAM

Because the computational problem in plant design consists of making a large number of separate, relatively simple

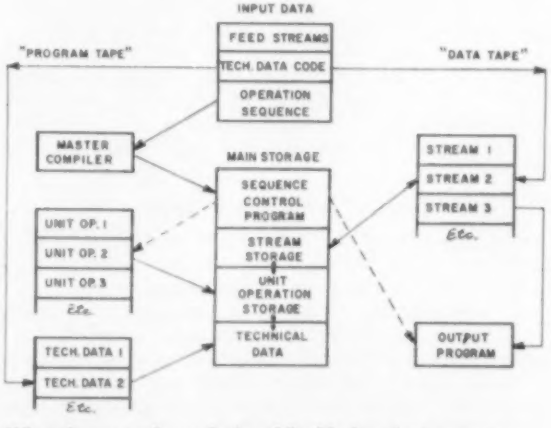


FIG. 1. Summary of overall plan of flexible flow sheet program.

calculations, the development of independent computer programs for each of the basic unit operations would seem a logical approach. But carrying out a typical design with such programs proves unwieldy. The reasons are several. Because of the basic simplicty of each operation, the paper work and form-filling required is disproportionate to the returns. An engineer can frequently obtain results sooner by hand than from a busy computer. Since each step may be determined by results of the previous step, a non-productive lag can arise while waiting for computer results. In the calculation of a recycle system by successive trials, the need for constant resubmittals of essentially the same sequence of problems can become a nuisance.

A more realistic approach to the problem, and one that will lead to efficient and profitable use of computers in plant design, is the development of large-scale, completely integrated programs. The engineer should have to make only a single submittal to the computer, and be able to turn his attention to other, more important matters while the computer is calculating the complete design, including unit

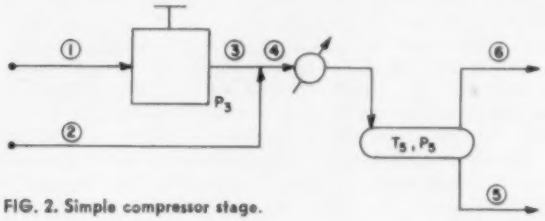


FIG. 2. Simple compressor stage.

operations, recycles, iterations, and trial-and-errors where necessary. The burden can be lifted from the engineer.

An integrated computer program should be capable of doing each of the following:

1. Accept the necessary information regarding the plant in the language of the engineer.
2. Translate this information into computer language.
3. Assemble the necessary unit operations.
4. Provide the linkages among these operations as indicated by the flow sheet.
5. Carry out the required calculations.
6. Tabulate the results.

The keynote of such a system is flexibility. The program would have to be sufficiently flexible to handle any combination of flow and conditions in a unit, any of a number of sets of technical data, and any number of computer routines for unit opreations. Criteria for convergence, tests for recovery, and methods of adjusting variables would have to be sufficiently flexible and general to apply to any flow scheme. At the M. W. Kellogg Company, such a flexible program is under development. The first phase, process design calculations, is in operation and is being used extensively by the process engineering department. Work on mechanical design and cost estimating is in progress and will be integrated with process design to produce a complete system.

FLEXIBLE FLOWSHEET SYSTEM

The basic pattern of the Kellogg flexible flowsheet program is indicated in Fig. 1. Some of the features are:

Input Data for a problem consists of three parts:

1. Feed Streams: Composition, flows, etc. are stored directly on the Data Tape for use as required.
2. Technical Data Code: This identifies to the computer the type of materials in the systems and the appropriate physical data required (enthalpies, equilibrium, constants, molecular weights, etc.). The code activates the proper pre-programmed technical data "package" stored on the Program Tape and places it in main storage for permanent usage during the calculations.
3. Operation Sequence: This defines the flow scheme of the plant in engineering terms. It is translated by a master compiler which constructs and deposits in main storage a corresponding "Sequence Control Program."

Master Compiler. The heart of the entire system is the master compiling program. Its principal function is to translate the input data from engineering language into computer language and to construct a sequence control program.

The Sequence Control Program. This program, once compiled and placed in main storage, serves as the coordinator of the entire calculation. It brings the proper streams from the Data Tape, and the proper unit operation from the Program Tape (Fig. 1), and then releases control to the unit operation program. When the unit operation is completed, control is returned to the Sequence Control Program which stores the result streams on the Data Tape and goes on the next unit operation. At the completion of the entire program, control is switched to an Output Program which prints the results.

Unit Operations. These are self-contained general purpose routines required for the calculation of any process. They are stored on the program tape. Under the control of the Sequence Control Program, they are brought individually as needed into the main storage areas.

The unit operation routines incorporated in the flexible flow sheet system fall into three basic categories:

1. Process Operation
2. Data Manipulation
3. Closure

The process operations are self-contained routines which calculate flashes, bubble and dew points, heat exchange,

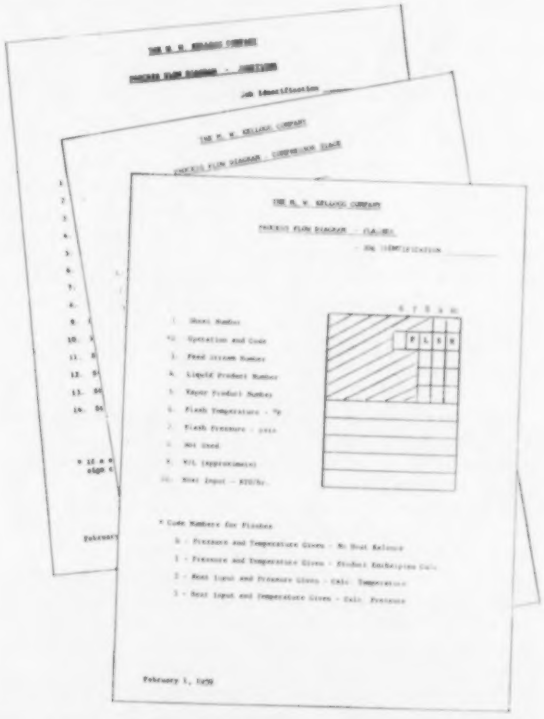


FIG. 3. Process flow diagram — unit operation form.

compression, joining of several streams into a single one, and so on. They are programmed in as general a fashion as possible to handle any stream the engineer specifies and to operate with any technical data package available.

Second category of routines is provided for the transfer of information within the system. These data manipulation routines allow the engineer to modify and transfer items such as temperature, pressure, enthalpy, phase, or specified components in any manner desired. For instance, if the operating pressure in a tower is determined by a previous flash, rather than specified by the engineer, the calculated pressure of the flash may be transferred to the tower by one of these routines.

Third group of unit operations in the system is devoted to closure methods. These programs are provided to handle recycles and other special conditions for which iterative procedures are required. The objective of these operations is to bring about some specified heat balance, material balance or key component recovery, by adjusting a suitable variable. These operations are decision-making in nature. They investigate the imbalance in the system, adjust flow rates or operating conditions, and force the recalculation of the system until the deviations are reduced to a specified tolerance. Once this tolerance is met, they permit the calculation to proceed in sequence.

PUTTING THE SYSTEM TO WORK

To illustrate the manner in which an actual sequence of unit operations can be put together, consider the simple compressor stage shown in Fig. 2. After numbering the streams for identification, and providing data on the feed streams, the engineer fills out form sheets (Fig. 3). These sheets provide an abbreviated way of saying:

1. *Compress* stream 1 to stream 3 at pressure P_3. (The computer will calculate horsepower and the temperature and enthalpy of stream 3.)
2. *Join* stream 2 and 3 to form stream 4.
3. *Flash* stream 4 adiabatically. (The computer will determine the line temperature and the compositions of liquid and vapor entering the condenser.)
4. *Flash* stream 4 into liquid stream 5 and vapor stream 6 at temperature T_5 and pressure P_5. (The computer will find the flash compositions, flows and enthalpies and determine the condenser duty.)

Output tabulated by the computer is shown in Fig. 4.

Str. 67 (liq)		Str. 68 (vap)	
335.0	psia	335.0	psia
60.0	deg F	60.0	deg F
131168.	btu/hr	321169.	btu/hr
23.58	mol/hr	35.15	mol/hr
882.59	lb/hr	1102.72	lb/hr
37.43	MW	31.37	MW
.566	SG		
FLASH			
Vap. Str. 68			
Heat in	452337.	btu/hr	
V/L	1.49	mol/mol	

FIG. 4. Sample computer printout.

While the problem of putting together a specific operational sequence from the basic unit operations offers no fundamental difficulties, it does require some familiarity with the structure of the system. A means of bypassing this requirement is to plan complete flowsheets in advance. In this manner the engineer can be supplied with pre-planned packages, to which he adds relevant process information such as flows, pressures, and temperatures. This is particularly valuable for certain types of flow sheets where most of the process alternates can be anticipated in advance. There is no limit to the number of alternate schemes for a given process that can be packaged in this manner.

However, when the complexity of the plant is great and the number of process alternates virtually unlimited, the pre-planned flowsheet is impractical, and another approach must be devised. Certain sub-sections of many plants commonly occur in the same pattern. For example, a compressor stage normally consists of a compressor followed by a condenser and flash drum with the possibility of side streams; the balance around a tower involves a certain combination of equilibrium calculations, heat balance, and the possibility of bottoms-feed exchange. To supplement the system of unit operations linked together in a flexible manner, pre-planned **process combinations** linked together in the same flexible manner can be used. Each of these combinations is specified by a single special-purpose form sheet (Fig. 5) which replaces several unit operation form sheets (Fig. 3). Submittal of one process combination form to the computer will generate the required unit operation sequence automatically.

Output tabulated by the computer is shown below.

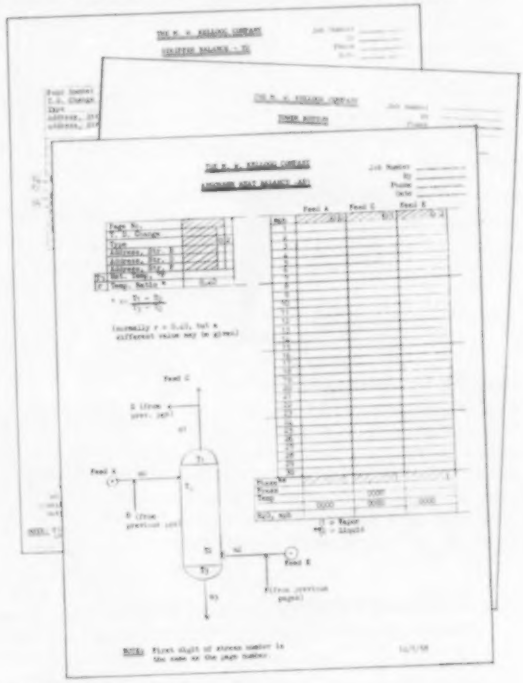


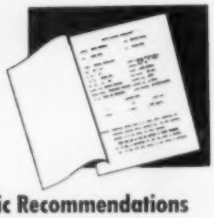
FIG. 5. Process combination form.

The use of planned process combinations has greatly enhanced the general utility of the entire system. A complete plant can be assembled much more easily using a relatively small number of complex basic combinations than a large number of the simple unit operations. Engineers with virtually no experience with the computer have put together quite complicated systems built up from these combinations.

The system described here has been in operation at The M. W. Kellogg Company for about 1½ years. It has enabled Kellogg engineers to obtain in a shorter time more information about a given process and more detailed calculations of greater accuracy. Using the computer as a tool, an engineer undertakes a much more complete study of process alternates than in the past. He pins down precisely many empircal designs once considered too complex to calculate. Since the computer can perform the tedious process design calculations, the engineer practices better engineering. He places greater emphasis on the creative aspects of his profession, an area in which the machine cannot compete. The result has been exactly as anticipated . . . **improved process design.** ★ ★ ★

How Oakite ECP engineered cleaning program speeds turnarounds, cuts maintenance costs

Oakite ECP stands for Engineered Cleaning Programs. It is chemical cleaning tailored individually for specific refineries to give the shortest turnaround time consistent with good results. Each ECP takes into account a refinery's particular conditions, equipment, through-put. It itemizes the problems involved, and suggests methods and materials to solve those problems. In putting the chemistry of cleaning to work, it utilizes the experience of Oakite engineers, the latest research results and the skills of laboratory and field technicians.



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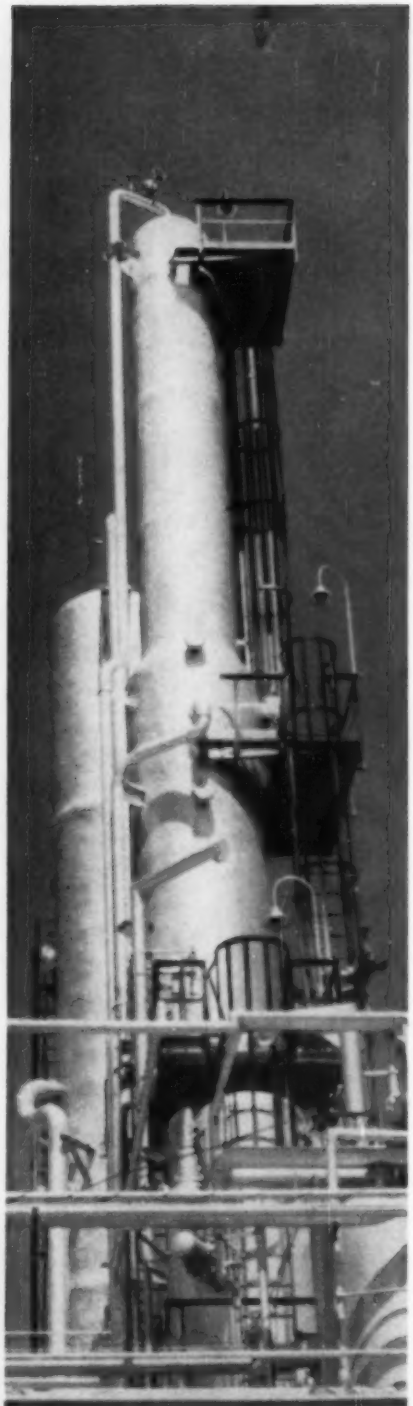

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Simulating Plant Studies with Computers

Butadiene plant balance investigations demonstrate what can be done . . . and how . . . with confidence

D. A. Gibson **E. E. Ludwig**
The Dow Chemical Company, Freeport, Texas

PROCESS ENGINEERS are continually looking for design parameters and numerical guides from which estimates can be made of process equipment sizes and related performance. Some cases that are most common to the pilot plant, research, production, or process design engineer are:

1. Estimation of process equipment sizes for research or pilot plant operation.
2. Estimation of equipment required for expansion of existing plants.
3. Estimation of equipment sizes for new plants.
4. Evaluation of existing plants in regard to changes in unit processes and/or feed stocks.

A few common results required for estimation or design purposes in an example butadiene process evaluation are:

1. Component split and overhead and bottoms flow rates in a given number of distillation trays with an operable reflux rate. From this information, column diameters and heights, condenser and reboiler areas, pump heads and capacities can be approximated.
2. Component distribution from a reactor under specified operating conditions enable estimation of quench system sizes, refrigeration or endothermic requirements, compression requirements, and make-up flow rates.
3. Component split and flow rates in absorbers and strippers with specified trays enable estimation of lean oil and stream flows, together with column heights and diameters.
4. Extract and raffinate compositions and flow rates can be predetermined for a given solvent extraction system of set selectivity and number of contact stages, which enable line, pump, and vessel size estimates.

The problem of estimating "once-through" processes is relatively quick and easy by making use of the numerous methods presented in the literature. When one or more recycle streams are required in a process, the problem becomes quite complicated. Estimations of flow rates under these conditions, assuming a "once-through" process, may be in error by several hundred percent. Solving a problem of this magnitude to a steady state condition by hand calculations in a reasonable length of time and with any degree of accuracy would require more time and man power than any company would normally be willing to invest.

How then can the process engineer prepare the plant balance studies in a short time and yet have confidence in his results? The Process Engineering Section of The Dow Chemical Company's Engineering Department in Freeport, Texas has made use of a medium-size digital computer in simulation of a butadiene process.

This paper is a brief discussion of the process, calculations, programming, convergence, and a summary of an actual application to a plant problem.

The object here is to present one example of how this type of problem was attacked and solved and to suggest that this may lend some insight into similar problems and their solution. Solution of the study and computer program required one man for approximately four months, including calculation method analysis, programming, and "debugging." Approximately three weeks were then utilized in running thirty cases involving various feed stocks and combinations of process equipment.

DESCRIPTION OF PROCESS

Fig. 1 presents the basic processing scheme for the butadiene process under consideration. Assumed specifications and conversions are presented as operating guide lines, and do not necessarily represent optimum performance for each unit.

The process consists of:

1. Five distillation columns
2. One absorber
3. One stripper
4. Two reactors
5. Two two-stage partial condensers
6. Two liquid extraction units
7. One quench system
8. Two side-stream withdrawals
9. Three recycle streams

System specifications for individual unit performance were determined from actual plant operating data. In cases where the engineer is starting with no preliminary or guide line data, more preliminary study is required utilizing published literature or laboratory information to set initial equipment specifications. In this type of situation, the computer encourages developmental studies to correct initial estimates of specifications by following the effect of changing specifications on the over-all process performance.

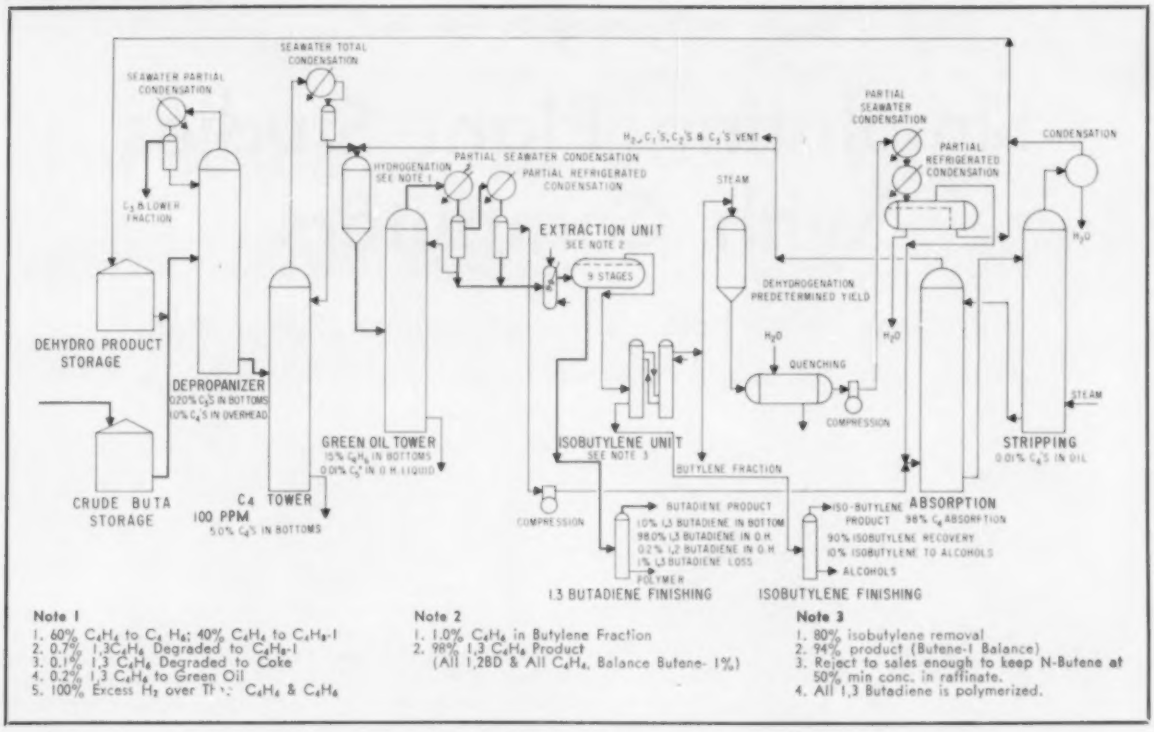


FIG. 1. Butadiene plant flow sheet.

CALCULATION FLOW SHEET

Fig. 2 shows a simplified calculation "flow sheet." The computer program was constructed or assembled similar to an actual plant. Each phase or unit was designed and programed separately, run in (or "debugged") separately, and then the entire plant (or program) was assembled or tied together as a unified computer program, with recycle streams tied in at the proper locations. The plant was "started up" on the computer and convergence on "steady state" condition achieved after a period of operation. This subject is more fully described in the section on "Convergence."

The problem described herein, even with the short methods of calculation, is too large for a medium-size computer (approximately 860 net working storage program locations using the interpretive system then available). Approximately 2000 storage locations were required. In this case, punched paper tape external storage was utilized to carry overflow program steps by making adaptations to the standard interpretive system.

CALCULATION PROCEDURES

As a matter of interest, some simplified methods of estimation calculations (used in the specific problem) are presented in the following discussion. The calculations are:

1. Green oil tower distillation
2. Absorber
3. Dehydrogenation reactor
4. Butadiene extraction unit
5. Flash calculations for partial condensers

Examples presented here may suggest other methods of estimating component splits and flow rates for other types of process equipment. They do not necessarily represent the best or only methods for approximating this type of equipment.

1. **Green Oil Tower:**

All columns in the plant are calculated in a manner similar to that to be used for this example. This column varies from the other columns in the plant in that it operates with a partial condenser and reflux must be accounted for. The reflux ratio is set.

We can assume that essentially all the feed will be taken overhead and that the ratio of components in the feed will be equal to the ratio of components in the overhead.

By Fenske's Equation:

$$\left(\frac{x_l}{x_h}\right)_D = \left(\frac{x_l}{x_h}\right)_W (\alpha_{lh})^n$$

Where: x_l = Mol fraction of *light key* in liquid
x_h = Mol fraction of *heavy key* in liquid
α_{lh} = Relative volatility of the *light key* relative to *heavy key*

Assuming:

$$\left(\frac{x_l}{x_h}\right)_D = \left(\frac{z_l}{z_h}\right)_F$$

$$\left(\frac{x_l}{x_h}\right)_W = \frac{\left(\frac{z_l}{z_h}\right)_F}{(\alpha_{lh})^n}$$

Setting the composition of the light key in the bottoms allows the computation of the remaining component compositions by:

$$x_{iW} = \frac{(x_l)_W (\alpha_{li})^n}{\left(\frac{z_l}{z_i}\right)_F}$$

$$\sum_1^n x_{iW} = 1.0$$

$$\sum_1^n x_{iW} \text{ (not including 1)} = 1.0 - x_{lw}$$

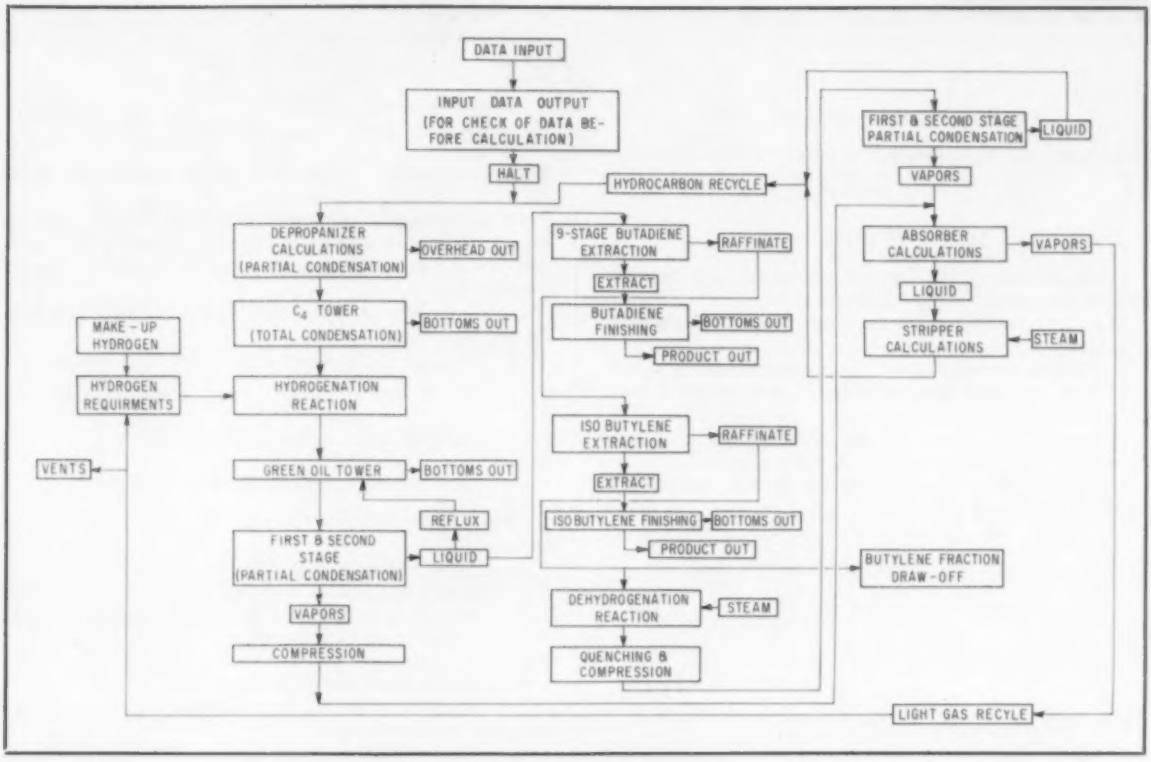


FIG. 2. Flow sheet for calculation sequence.

$$\frac{(x_i)_W}{z_i}\left[z_1(\alpha_i)_1^n + \ldots + z_n(\alpha_i)_n^n\right] = 1.0 - x_{1w}$$

Where: Subscript n refers only to the nth component.

Setting the column operating temperature at 50 C and solving above equation for number of theoretical stages by trial and error gives:

$$n = 7.2 \text{ theoretical trays}$$

Tower Specifications:

15.0% 1,3 C_4H_6 in bottoms
0.01% C_5^+ in overhead

The mol fraction of the other components in the column bottoms can now be calculated from:

$$(x_i)_W = \frac{(x_{1W})\ (\alpha_{11})^{7.2}}{\left(\frac{z_1}{z_1}\right)_F}$$

From an Over-All Material Balance:

$$\sum_1^{11}(x_i)_D = 1.0$$

$$\sum_1^{10}(x_i)_D = 1.0 - x_{11D} = .9999$$

Since the amounts of light components in the bottoms will be negligible, we can say:

$$\sum_4^{10}(x_i)_D = .9999 - \sum_1^{3}(x_i)_D$$

$$x_{1D} = \frac{Fz_1 - Wx_{1W}}{D}$$

$$F\sum_4^{10} z_i - W\sum_4^{10}(x_i)_W = 0.9999D - D\sum_1^{3}(x_i)_D$$

When the composition of light components is zero in the column bottoms:

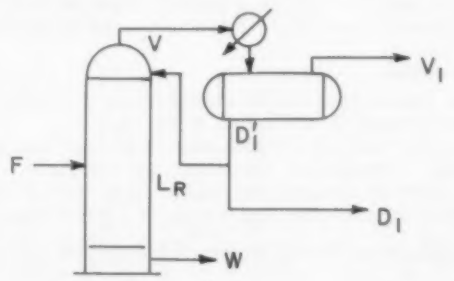
$$Fz_1 = D\,(x_i)_D$$

$$D = F - W$$

It follows that:

$$W = \frac{F\,(0.9999 - \sum_1^{10} z_i)}{0.9999 - \sum_4^{10}(x_i)_W}$$

The columns with total condensation can be solved with a technique similar to that above. If reflux must be accounted for, the following calculations must be performed.



Plant Operation

In order to account for the effect of reflux ratio on the over-all column material balance,

$$V + W - L_R = F$$

$$V\,(y_i)_V + W\,(x_i)_W - L_R\,(x_i)_D = Fz_i$$

As first guess, L_R is set equal to zero.

$$V + W = F$$

$$V\,(y_i)_V + W\,(x_i)_W = Fz_i$$

Compositions of the column overhead and bottoms streams are computed as previously shown.

Once the composition of the bottoms liquid is specified, it is assumed held constant.

Calculated overhead vapor is then condensed in a partial condenser and the vapor-liquid split calculated by a flash vaporization determination.

From the flash calculation, the amount and composition of both the liquid and vapor streams are specified.

Having set the reflux ratio (for this example use a reflux ratio of 0.10):

$$\frac{L_R}{D_i} = 0.10 \therefore D_i = \frac{L_R}{0.10}$$

$$L_R + D_i = D'_i$$

$$L_R = \frac{D'_i}{11}$$

Again from an over-all material balance:

$$V + W = F + L_R$$

Or for any component:

$$Vy_{iV} + Wx_{iW} = Fz_i + L_R\,x_{iD'_1}$$

Having specified the mol fraction of heavy component in the overhead vapor and having calculated its mol fraction in the bottoms liquid, we have:

$$y_{11V} = .0001$$

x_{11W} = value determined by problem

$$V\,(.0001) + (F + L_R - V)\,(x_{11W}) = Fz_{11} + L_R\,x_{11D'_1}$$

$$V = \frac{F\,(.71312 - z_{11}) + L_R\,(.71312 - x_{11D'_1})}{x_{11W}}$$

The new bottoms liquid is determined by:

$$W = F + L_R - V$$

The new overhead vapor composition is determined by:

$$y_{iV} = \frac{Fz_i + L_R\,x_{11D'_1} - Wx_{iW}}{V}$$

for other components.

The new reflux is then checked against the previously calculated value and compared to a given tolerance. If within this tolerance, the column is satisfied; if not, we return to the beginning and repeat calculations until a balance is achieved.

2. **Absorber:**

The specification for the absorption column is that 98 percent of the C_4's be absorbed in the oil.

At a L/V ratio of 2.5 and operating at 100 F and 45 lb pressure, a satisfactory absorption rate is achieved.

In order to estimate the number of theoretical stages necessary for absorption, use is made of a plot in Reference 2. Equations are derived relating 1/A and $\frac{Y_{n+1} - Y_1}{Y_{n+1} - Y_o}$. The equations are:

For two theoretical stages:

$$y = -.392\,x + 1.051$$

For four theoretical stages:

$$y = -.372\,x + 1.170$$

The constants m and b in the same equation (which is of the form $y = mx + b$) are plotted.

By calculating the percent C_4's in the overhead vapor at varying number of theoretical stages and plotting, it is seen that 2.9 theoretical stages are required to meet column specifications.

For 2.9 theoretical stages, the values of m and b required for the equation:

$$y = -0.383\,x + 1.120$$

Where:

$x = 1/A$ or $\frac{1/L}{K_{iV}}$ for each component

y = amount of each component absorbed

3. **Dehydrogenation Reactor.**

Specifications:

a. Maximum flow rate of 100 mols per hr to unit.

b. Material balance on unit based on a given balance from actual plant data and is a conservative estimate of what might be expected.

Basis of Calculations:

Feed stream from extraction units.

The following equations derived from a given dehydrogenation unit operating yield:

Letting: $T = 4\,[.0134\,(i\text{-}C_4H_{10})_{Feed} + .7777\,(C_4H_8\text{-}1)_{Feed} + .2089\,(Cis\ \&\ Trans\ C_4H_8)_{Feed}]$

Note: T represents a measure of the rate of change of the components for a given condition of catalyst temperature, pressure, etc.

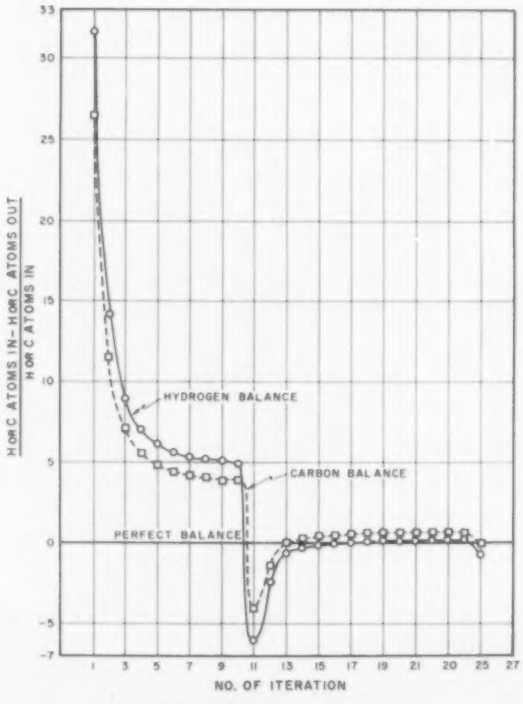


FIG. 3. Convergence chart.

a. C_2 Fraction Balance:

$$(C_2)_{Product} = 0.0532T$$

b. C_3 Fraction Balance:

$$\left[\frac{.0557T}{3}\right] + (C_3)_{Feed} = (C_3)_{Product}$$

c. Isobutane Balance:

$$\left[\frac{4\,(i-C_4H_{10})_{Feed} - (.7777)\,4\,(C_4H_8-1)_{Feed}}{4}\right] = (i-C_4H_{10})_{Product}$$

d. Isobutylene Balance:

$$\left[\frac{.023T}{4}\right] + (i-C_4H_8)_{Feed} = (i-C_4H_8)_{Product}$$

e. 1-Butene Balance:

$$\left[\frac{4\,(C_4H_8-1)_{Feed} - (.7777)\,4\,(C_4H_8-1)_{Feed}}{4}\right] = (C_4H_8-1)_{Product}$$

f. 1,3 Butadiene Balance:

$$\left[\frac{.8578T}{4}\right] + [1,3\,C_4H_6]_{Feed} = (1,3\,C_4H_6)_{Product}$$

g. Butane Balance:

$$\left[\frac{.0025T}{4}\right] + (C_4H_{10})_{Feed} = (C_4H_{10})_{Product}$$

h. Cis & Trans Butene Balance:

$$\left[\frac{4\,(C\&T\,C_4H_8)_{Feed} - (.2089)\,4\,(C\&T\,C_4H_8)_{Feed}}{4}\right] = (C\&T\,C_4H_8)_{Product}$$

i. Vinyl-Acetylene Balance:

$$\left[\frac{.0025T}{4}\right] + (C_4H_4)_{Feed} = (C_4H_4)_{Product}$$

j. C_5^+ Fraction Balance:

$$\left[\frac{.0053T}{5}\right] + (C_5^+)_{Feed} = (C_5^+)_{Product}$$

k. Hydrogen Balance:

$$\frac{\sum_{1}^{11}(H\ Atoms)_{Feed} - \sum_{3}^{11}(H\ Atoms)_{Product} + 2\left[\frac{.6667\,(C_2)_{Product}}{8}\right]}{2} = [H_2]_{Product}$$

4. **Butadiene Extraction Unit:**

The following was extracted from Reference 3:

a. Absorption of saturated hydrocarbons is quite small in cuprous salt solution.

b. Reactions of diolefins (conjugated and nonconjugated types) and α type mono-olefins:

Diolefin:

$$CH_2=CH-CH=CH_2 + Cu_2^{++} \rightleftarrows C_4H_6\cdot Cu_2^{++}$$

α – Olefin:

$$CH_2=CH-CH_2-CH_3 + Cu_2^{++} \rightleftarrows C_4H_8 + Cu_2^{++}$$

$$K_P = \left(\frac{U\cdot Cu_2^{++}}{Cu_2^{++}\cdot P_u}\right)$$

β – Olefin:

$$2\,CH_3-CH=CH-CH_3 + Cu_2^{++} \rightleftarrows 2\,C_4H_8\cdot Cu_2^{++}$$

$$K_P = \left(\frac{2U\cdot Cu_2^{++}}{Cu_2^{++}\cdot P_u^2}\right)$$

$(U\cdot Cu_2^{++})$ = Molal concentration in the solvent of unsaturated hydrocarbon-copper complex.

(Cu_2^{++}) = Uncombined cuprous copper.

(P_u) = Partial pressure of the unsaturated hydrocarbon.

The nomenclature used for the derivations in this section is separate from that used in the other sections of this report and is as follows:

L = Mols Cu^{++} in

B_i = Mols butadiene in

Bu_i = Mols butylene in

I = Mols inerts in

α = Fraction of B_i reacted at equilibrium

β = Fraction of Bu_i reacted at equilibrium

αB_i = Mols B_i reacted

βBu_i = Mols Bu_i reacted

$\alpha B_i + \beta Bu_i$ = Mols Cu^{++} reacted

$L-(\alpha B_i + \beta Bu_i)$ = Mols Cu^{++} unreacted

P_B = Partial pressure of butadiene

P_{Bu} = Partial pressure of butylene

Superscript o = Refers to original condition

Assume Raoult's law for vapor pressure of butylene and butadiene.

$$P_B = \left[\frac{(1-\alpha)\,B_i}{(1-\alpha)\,B_i + (1-\beta)\,Bu_i + I}\right] P_B^{\circ}$$

$$P_{Bu} = \left[\frac{(1-\beta)\,Bu_i}{(1-\alpha)\,B_i + (1-\beta)\,Bu_i + I}\right] P_{Bu}^{\circ}$$

Letting:

$$K_{P_i} = \left(\frac{U_i\cdot Cu^{++}}{Cu^{++}\cdot P_i}\right)$$

Then:

$$K_{P_B} = \frac{\alpha B_i}{(L-\alpha B_i-\beta Bu_i)\left[\frac{(1-\alpha)\,B_i}{(1-\alpha)\,B_i + (1-\beta)\,Bu_i + I}\right] P_B^{\circ}}$$

A similar equation can be derived for $K_{P_{Bu}}$.

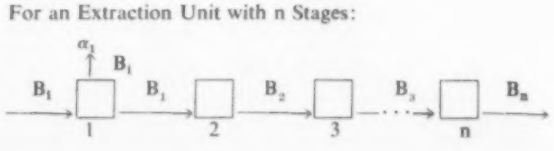
Then:

$$\frac{K_{P_B}}{K_{P_{Bu}}} = \frac{\frac{\alpha}{(1-\alpha)\,P_B^{\circ}}}{\frac{\beta}{(1-\beta)\,P_{Bu}^{\circ}}}$$

And:

$$\frac{\left(\frac{\alpha}{1-\alpha}\right)}{\left(\frac{\beta}{1-\beta}\right)} = \frac{K_{P_B}P_B^{\circ}}{K_{P_{Bu}}P_{Bu}^{\circ}} = \sigma$$

For an Extraction Unit with n Stages:



$$B_1 = (1-\alpha_1)\,B_i$$

$$B_2 = (1-\alpha_2)\,B_1 = (1-\alpha_2)\,(1-\alpha_1)\,B_i$$

$$B_n = B_i \prod_{i=1}^{n} (1-\alpha_1)$$

$$\overline{Bu_n} = Bu_i \prod_{i=1}^{n} (1-\beta_1)$$

$$\frac{Bu_n}{B_n} = \frac{Bu_i}{B_i} \prod_{i=1}^{n} \left(\frac{1-\beta_1}{1-\alpha_1}\right)$$

Assume that α is constant for all stages.
Then:

$$\frac{Bu_n}{B_n} = \frac{B_{ni}}{B_i}\left(\frac{1-\beta}{1-\alpha}\right)^n$$

And:

$$B_n = B_i\,(1-\alpha)^n$$

$$\frac{B_u}{B_i} = (1-\alpha)^n = 1-\alpha_T$$

Where α_T is the over-all fractional recovery of butadiene specified and $n = 9$:

$$1-\alpha = \sqrt[n]{(1-\alpha_T)} = \delta$$

$$\alpha = 1-\delta$$

$$\frac{\alpha}{1-\alpha} = \frac{1-\delta}{\delta} = \left(\frac{\beta}{1-\beta}\right)\sigma$$

$$\beta = \frac{1-\delta}{\sigma\,\delta + 1 - \delta}$$

Then:

$$\frac{Bu_n}{B_n} = \frac{Bu_i}{B_i}\left[\frac{\sigma}{\sigma\,\delta + 1 - \delta}\right]^n$$

5. Sea Water and Refrigerated Partial Condensers:

Calculation of the partial condensers is assumed satisfied by an equilibrium flash calculation. This is computed by the following method:

At equilibrium:

$$\frac{y_i}{x_i} = K_i$$

For a given flash:

$$F = V + L$$

For a given component:

$$Fz_i = Vy_i + Lx_i$$

Then:

$$x_i = \frac{Fz_i}{VK_i + L} = \frac{F}{V}\left[\frac{z_i}{K_i + L/V}\right]$$

$$x_1 + x_2 + x_3 + \ldots + x_{11} = \sum_1^{11} x = 1.0$$

$$\sum_1^{11} \frac{z_i}{K_i + L/V} = \frac{V}{F}$$

$$\frac{V}{F} = 1.0 - L/F$$

$$\sum_1^{11} \frac{Z_i}{K_i + L/V} = 1.0 - L/F$$

Dividing both sides by $1 - L/F$:

$$\sum_1^{11} \frac{z_i}{\frac{L}{F} + \left(1 - \frac{L}{F}\right)K_i} = 1.0$$

If we let:

$$\chi = 1.0 - \sum_1^{11} \frac{z_i}{L/F + (1 - L/F)\,K_i}$$

At the correct L/F ratio:

$$\chi = 0$$

We can use this as a measure of convergence and also to estimate next approximation at liquid rate.

$$\Delta L = -\frac{1 - \left[\sum_1^{11} \frac{z_i}{L/F + (1 - L/F)\,K_i}\right]}{\sum_1^{11} \frac{f_i\,(1-K_i)}{(L + V\,K_i)^2}}$$

$$L_1 = L_0 - |\,\Delta L\,|$$

With the new liquid rate, calculate a new χ, calculate its nearness to 1.0. Repeat calculations until a satisfactory liquid-vapor split is reached.

Based on the correct L/V ratio, composition of the liquid and vapor are calculated by:

$$l_i = \frac{f_i}{1 + \frac{K_i V}{L}}$$

$$v_i = f_i - l_i$$

This procedure is used with the calculation of the green oil tower previously described.

TABLE 1. Computer Output.

Crude Butadiene Feed		Depropanizer						C_4 Tower			
Component No.	Mols/Hr. Flow	Feed	Overhead		Bottoms	Feed		Overhead		Bottoms	
	*1	2	3		4	5		6		7	
1	12.00000	1 12.00000	1 12.00000	1	12.00000	1 12.00000	1	12.00000	1	12.00000	
2	12.00000	2 12.00000	2 12.00000	2	12.00000	2 12.00000	2	12.00000	2	12.00000	
3	51.63800	3 51.63800	3 51.60775	3	50.30248	3 50.30248	3	50.30248	3	12.00000	
4	51.11900	4 51.11900	4 48.89169	4	51.11811	4 51.11811	4	51.11811	4	12.00000	
5	52.11810	5 52.11810	5 49.11770	5	52.11798	5 52.11798	5	52.11797	5	48.11274	
6	52.19000	6 52.19000	6 48.97524	6	52.18990	6 52.18990	6	52.18987	6	48.28701	
7	52.98360	7 52.98360	7 49.40537	7	52.98319	7 52.98319	7	52.98302	7	49.17736	
8	51.40500	8 51.40500	8 47.41879	8	51.40496	8 51.40496	8	51.40475	8	48.20731	
9	52.14040	9 52.14040	9 47.36821	9	52.14040	9 52.14040	9	52.14021	9	49.18481	
10	51.17700	10 51.17700	10 46.46420	10	51.17700	10 51.17700	10	51.17676	10	48.23299	
11	50.79000	11 50.79000	11 12.00000	11	50.79000	11 50.79000	11	49.19685	11	50.77032	
	53.15739	53.15739	51.61496		53.15124	53.15124		53.15043		50.81086	

*Stream Number

Machine Runs

Inasmuch as the evaluation of an existing process was to be made, both from a process equipment and a crude feed stock standpoint, the computer program was written to allow for this flexibility. By using a system of flagging, the various process units could be bypassed or used, which ever was desired for the case in question. Of course, the crude feed composition and quantity could be varied very easily as part of the input data.

Approximately thirty cases of interest were run, varying processing schemes and crude feed rates. Some of the runs included elimination of the isobutylene recovery unit, the second stage condensation of green oil tower vents, the recompression of the green oil tower vents, and the depropanizer. Feed rates were varied as much as 300 percent, and various sources of hydrogen (for hydrogenation) were evaluated.

CONVERGENCE

By inspecting Fig. 1 or 2 it will be seen that there are several entering and leaving flows from the main process. These streams are as follows:

1. **Entering:**
   - a. Crude butadiene feed
   - b. Hydrogen to hydrogenator
   - c. Steam to dehydrogenator
2. **Leaving:**
   - a. Depropanizer overhead
   - b. C_4 tower bottoms
   - c. Green oil tower bottoms
   - d. Butadiene finishing column overhead and bottoms
   - e. Isobutylene finishing column overhead and bottoms
   - f. Butylene fraction withdrawal
   - g. Quench water
   - h. Light gas recycle vents

An over-all balance was set up on a carbon-hydrogen basis. When the number of carbon or hydrogen atoms in and out agree within a given tolerance, a steady state material balance is achieved.

It is interesting to observe the results of one machine case (shown in Fig. 3). The process is converging on a perfect balance through iteration No. 10. At this point the butylenes in the dehydrogenation feed have built up to a level which required a withdrawal of a portion of this stream. This adjustment is reflected in iteration No. 11. Convergence on a perfect balance is achieved after iteration No. 13. Steady state operation is shown for iterations No. 13-25. For this problem, one iteration required approximately thirty minutes of machine computation, so after eight hours of machine operation steady state conditions were reached.

It is possible in problems of this type to arrive at a state of oscillation or nonconvergence on a satisfactory balance. In cases of this type, a review of process requirements and specifications is in order and modifications must be made.

COMPUTER OUTPUT

Computer output of this problem was programed for selective choice. The two alternates were:

1. The type-out of the material balance around each piece of equipment for each iteration.
2. The type-out of only the over-all carbon-hydrogen balance for each iteration until steady state conditions are reached and then the final material balance for each unit is typed out.

A partial type-out for this problem is shown in Table 1. It will be noted that the computer output is in floating point form. Each process stream has an identifying number to tie the output data back to a master flow sheet with a predetermined code for identification of these streams. The mols of each component are given in every case. In order to avoid confusion, the order of components is maintained constant throughout.

Note that in the floating point print-out, for example, that 12.00000 is zero, 51.63800 is 6.38, and 49.18481 is 0.018481.

SUMMARY

Significance of this program is not in solving a complicated butadiene material balance, but in pointing the way to further studies of other processes by the basic techniques. Although the details presented here are peculiar to the prescribed conditions for the performance of this system, they say one thing, "it can be done, even if by approximations."

The computer is an exacting taskmaster as far as requiring each step in a program to be specific, but too many engineers are inclined to associate this exactness with problem precision. It has been shown that guide-line approximations to an otherwise near impossible task can be accomplished utilizing the exactness of the digital computer.

The "unit program package" concept demonstrated in handling this type of over-all program is a practical method of setting up basic parts of a problem or program and then connecting all of the parts together in the proper sequence. This also lends to tremendously easier program "debugging," as the small package is much easier to handle. This idea allows the same or similar package to be assembled for an entirely different process, basing the new program on the fundamentals of the package and replacing old parameters or specifications with new ones.

It is important to realize that if exacting calculations were required for each piece of equipment represented in Fig. 1, the computer would have to be one of the largest available, and the complexity of balancing would be multiplied several fold.

NOMENCLATURE

n	Number of theoretical stages
D	Mols of distillate
W	Mols of bottoms
F	Mols of feed
α	Relative volatility
x	Mol fraction component in liquid
z	Mol fraction component in feed
V	Mols of vapor
L	Mols of liquid
y	Mol fraction component in vapor
A	Absorption factor
K	Equilibrium constant
f	Mols individual components

Subscripts

l	Light key
h	Heavy key
i	Individual component
R	Reflux, raffinate, or recycle
F	Feed
E	Extract
D	Distillate
W	Bottoms
l_h	Light key relative to heavy key
l_i	Light key relative to any other component

Acknowledgment

E. H. Ivey established the basic production cycle and specifications prior to the computer development work.

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3. Morrell, C. E., et al., "Purification of Butadiene with Cuprous Salt Solution," *Trans. AIChE*, Vol. 42, p. 473, 1946.

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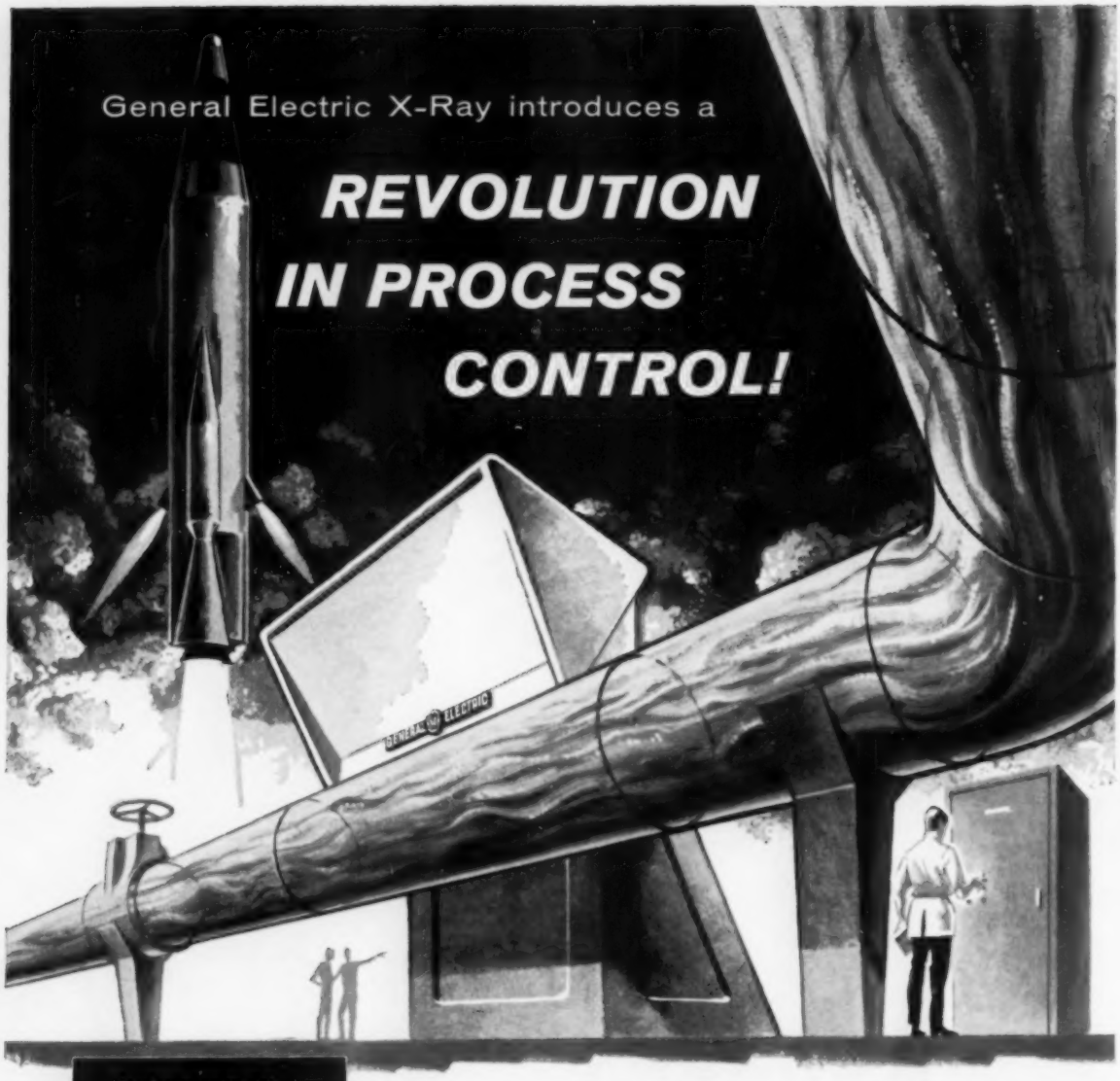
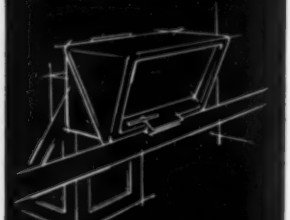


Analyzes materials continuously, or in individual samples —



- gases
- liquids
- solids
- mixtures of all three
- flowing slurries
- moving strips or wires
- a host of other forms

XEG scans materials in production, writes an on-the-spot x-ray analysis of up to 5 elements simultaneously

Here at last are means for wiping out a long-standing blind spot in process control: *XEG allows moment-by-moment surveillance of materials composition, right on the production line* — can detect and measure up to five elements at a time! XEG is a new and revolutionary *x-ray emission gage* — another exclusive product of General Electric "know how." Lends itself to more applications than you can imagine. Reveals quality . . . delivers facts on composition for rapid-fire, continuous feed-back to process control. Yet XEG requires no skilled operator! Ask your G-E x-ray representative for full details on potentials. Or simply write X-Ray Department, General Electric Company, Milwaukee 1, Wisconsin, Room RE-14.

Progress Is Our Most Important Product

GENERAL ELECTRIC

Phthalic Anhydride

Licensed by: Scientific Design Company, Inc.

DESCRIPTION: Phthalic anhydride is best produced from naphthalene in a fixed-bed catalytic vapor phase reaction. In sequence, referring to the diagram, molten naphthalene is vaporized, mixed with air, preheated by exchange with effluent gases, and fed to the reactor. The reactor cooling system (not shown) consists of molten salt circulating outside the tubes of the reactor.

Reaction effluent gases containing phthalic anhydride vapor are first cooled by a waste heat boiler generating steam, then used to preheat the feed mixture, and finally are cooled with cooling water to a temperature a few degrees above the dew point of phthalic anhydride. After leaving this cooler, the gases are passed through one of a pair of highly efficient switch condensers of novel design which condense solid crystals of phthalic anhydride. The condenser effluent gases, which may contain traces of by-products, are burned or water-scrubbed before release to the atmosphere. Meantime, in the alternate switch condenser, phthalic anhydride from the previous cycle is being melted out. The crude phthalic anhydride is treated to destroy contaminants and is then distilled under vacuum. The refined product may be flaked, pelletized, or packaged for shipment in liquid-full steel drums or tank cars.

This process was designed by Scientific Design Company, Inc.

MATERIALS OF CONSTRUCTION:

Mild steel and various stainless steels are used in contact with most materials in process. No higher-grade alloys or ceramic materials are required.

CHEMICAL REACTIONS:

Main Reaction —

$$C_{10}H_8 + 4\tfrac{1}{2}\ O_2\ (air) \rightarrow C_8H_4O_3 + 2\ CO_2 + 2\ H_2O$$

Principal Side Reaction —

$$C_{10}H_8 + 12\ O_2\ (air) \rightarrow 10\ CO_2 + 4\ H_2O$$

Minor Side Reaction —

$$C_{10}H_8 + 9\ O_2\ (air) \rightarrow C_4H_2O_3\ (\text{Maleic Anhydride}) + 6\ CO_2 + 3\ H_2O$$

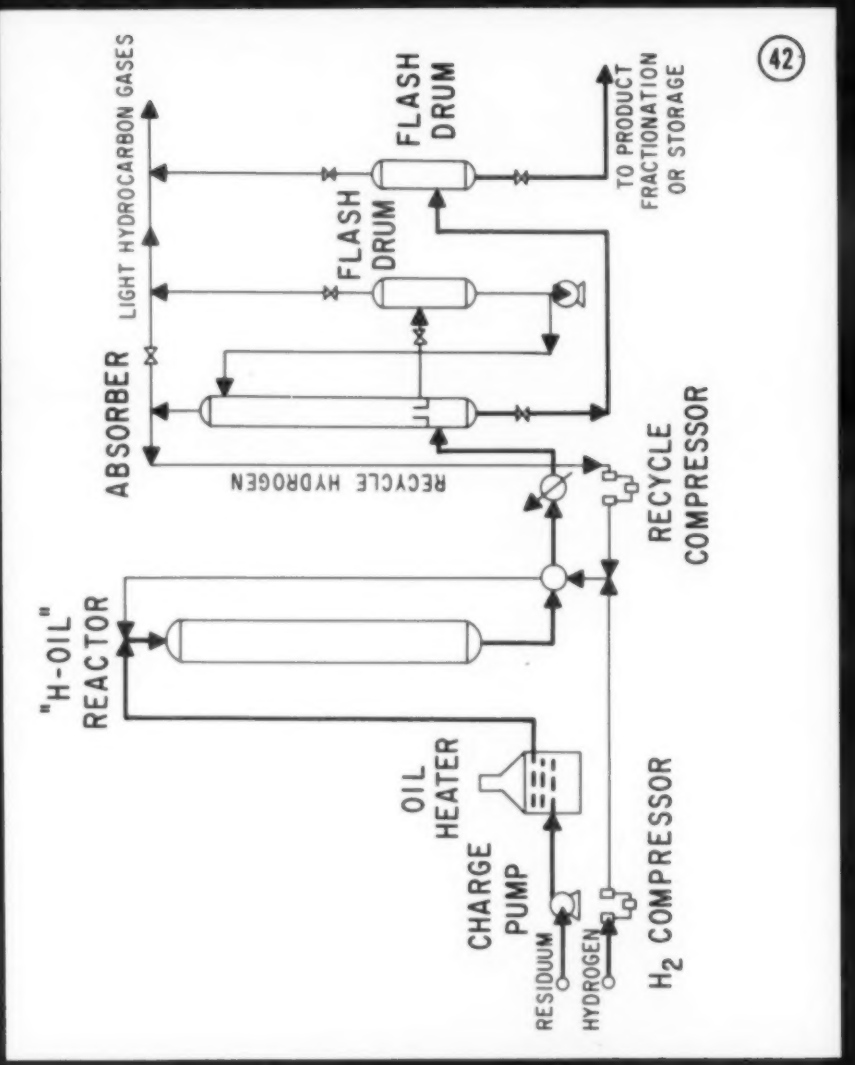
Note that almost all side reactions are much more exothermic than the desired main reaction. SD's highly selective oxidation catalyst thus aids temperature control and permits higher throughput rates in the reactor.

INVESTMENT AND OPERATING COSTS:

Must be secured from process licensor.

"H-Oil" Process

Licensed by: Hydrocarbon Research, Inc.



"H-Oil" Process

Licensed by: Hydrocarbon Research, Inc.

DESCRIPTION: The "H-Oil" process provides a method of desulfurizing and upgrading all types of petroleum stocks, particularly heavy sour crudes and heavy residues. The accompanying simplified flow diagram shows the basic equipment included in a "H-Oil" unit processing high-sulfur residuum feed stock. Slight modifications in the diagram would be made if distillate stocks or whole crudes are to be treated. Referring to the diagram, the residuum feed is pumped to system pressure, heated in a fired heater and charged to the "H-Oil" reactor. Hydrogen make-up, compressed to system pressure, joins with recycle hydrogen and is preheated against reactor effluent before entering the reactor.

The oil charge undergoes several types of reactions over the catalyst in the presence of hydrogen at high temperatures and pressures. Among these are desulfurization, nitrogen removal, upgrading of residuum into valuable distillate fractions, stabilization by satisfying unsaturated chemical bonds and a small amount of hydrocracking. The "H-Oil" reactor is limited to very small temperature differentials permitting the charge to be at the optimum reaction temperature throughout the entire catalyst bed. The high hydrogen partial pressure minimizes coke lay-down by the catalyst and permits long catalyst life even with heavy sour residues.

The reactor effluent is cooled by heat exchanger and cooling water. After a vapor-liquid separation is made, the recycle vapor is scrubbed free of H_2S and inerts in a lean oil absorber.

The lean oil is flashed in a drum to free the circulating oil of the light hydrocarbon gases. The liquid product from the separator also flows to a flash drum to remove dissolved light gases. The liquid product from the low pressure drum flows either to storage or to a fractionator to be separated.

The heart of the "H-Oil" process is the reactor which contains a catalyst bed. Various hydrogenation catalysts have been used in the "H-Oil" reactor depending on the particular feed stock and the distribution of end products that are desired. With an "H-Oil" reactor of special design which permits essentially isothermal operation, the catalyst consumption ranges from 20 to 80 bbls. per lb.

CHARGE:

Charge stocks may comprise all types of virgin and/or cracked stocks requiring desulfurization and upgrading. Whole crudes, residual stocks, or asphalt may be charged.

PRODUCT:

Light straight run distillates are almost completely desulfurized with essentially 100 volume percent yield. Heavier cracked distillates, sour crudes and heavy residual stocks are desulfurized to the extent of 75-90 percent and yields of 103-106 percent by volume are obtained depending on the type of charge stock. The synthetic crudes obtained from heavy sour residues are comparable to premium-priced sweet crudes.

YIELDS:

Typical yields from three different charge stocks are summarized below:

Charge	Kuwait Residuum	Boscan Crude	Furfural Extract Plus TCC Synthetic Tower Bottoms
Gravity, °API	8.3	10.5	9.1
Sulfur, wt. %	5.3	5.54	1.4
Ramsbottom Carbon, wt. %	17.2	15.5	1.3
Hydrogen Consumption			
SCF/bbl of charge	1500	950	2050
Product Yields			
C_1-C_2, wt. %	3.3	3.8	3.0
C_3s yield, vol. %	2.5	2.5	2.7
Gasoline (C_5 – 400°)			
Yield, vol. %	19.8	18.0	24.3
Gravity, °API	53.5	56.6	52.6
Sulfur, wt. %	negligible	<0.10	negligible
Aniline Point °F	130	128	127
Bromine No.	2.0	.....	0.6
No. 2 Distillate Fuel Oil (400°-650°)			
Yield, vol. %	24.0	26.0	42.4
Gravity, °API	34.7	34.9	32.4
Sulfur, wt. %	0.05	0.50	0.02
Aniline Point °F	136	127	133
Bromine No.	5.0	.....	3.9
Heavy Gas Oil			
Boiling Range, °F	650-975	650-975	650-850
Yield, Vol. %	29.1	42.0	31.2
Gravity, °API	21.7	21.7	.....
Sulfur, wt. %	0.64	1.02	0.08
Residue			
Boiling Range, °F	975°F+	975+	850°F+
Yield, vol. %	29.4	15.5	4.2
Gravity, °API	9.1	2.0	.....
Sulfur, wt. %	2.52	2.43	.....

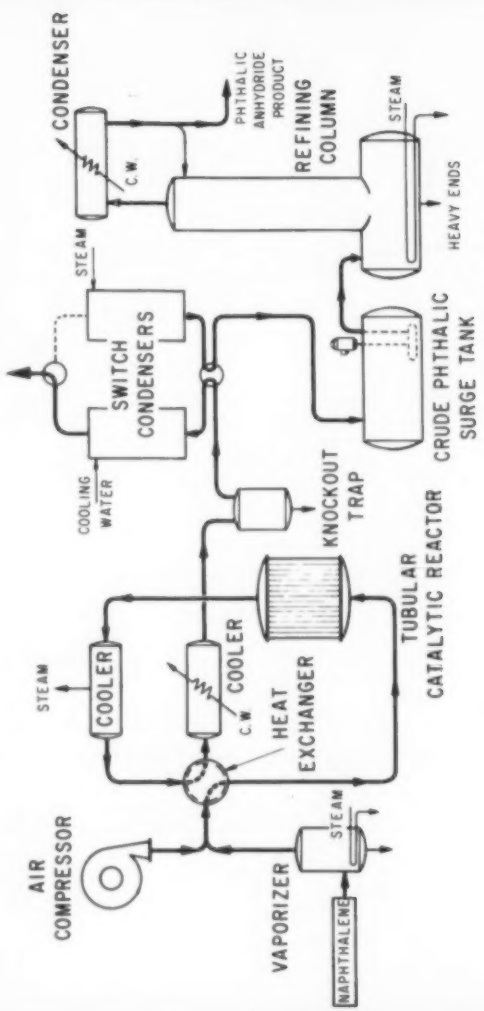
OPERATING COSTS:

Typical direct operating costs for a 5000 bbl per stream day unit are given below:

Feedstock / C_4 Liquid Product	Kuwait Residuum
Vol. %	104.8
Gravity, °API	26.9
Sulfur, wt. %	0.99
Operating Cost, ¢/bbl. Feed	
Power @ $0.008/FWH	1.4
Fuel @ $1.20/bbl	2.1
Water @ $0.013/1000 gal.	1.1
"H-Oil" Catalyst	4.0
Labor @ $180/day	3.6
Supervision @ 30% labor	1.1
Total Direct Operating Cost, ¢/bbl Feed	13.2

Phthalic Anhydride

Licensed by: Scientific Design Company, Inc.



What to look at when you . . .

Consider Integrated Computer Controls

Can the cost be justified? . . . What are the steps necessary to install computer control?

Dr. M. Phister, Jr.
The Thompson-Ramo-Wooldridge Products Co., Beverly Hills, California

ONE OF THE NEWEST and most widely discussed applications of computers today is that in which the computer is connected directly to a process and is given the full-time job of operating that process in the best possible way. The character of such a computer system is indicated in Fig. 1, where it will be seen that various process instruments feed information directly and automatically to the computer, the computer carries out previously specified calculations, and as a result of these calculations makes changes in process instrument settings. The computer communicates with the operator through a printer of some kind, and the operator, who continually monitors process and computer, may override the computer at will.

The block labelled "computer" in Fig. 1 may be an analog or a digital machine, and may be simple and cheap or very complicated and correspondingly expensive. The relative simplicity or complexity of the computer is of course determined by the complexity of the process involved and of the calculations which must be carried out to control it. This is a description of a class of computer control systems based upon a stored-program, general-purpose digital computer. There are two principal advantages to the use of a computer of this complexity. First, experience has shown that typical control calculations are very complicated, requiring a long series of arithmetic steps based on past conditions in the process as well as current conditions. Such calculations are easily handled by a digital computer, with its computing power, precision, and memory. Second, the flexibility of the stored-program computer is a great advantage. Processes are not static entities. They are constantly in a state of change and improvement. New instruments are employed, new process equipment is added, and the economic basis for operation of the process changes. These changes and others must be accommodated by the control system — the computations performed by the computer must change as the process changes. Such changes are very easily handled by a stored-program, digital computer.

Economics

The cost of a process control system based on a stored-program, digital computer may lie between $150,000 and $400,000, depending on the complexity of the process. A breakdown of costs for a typical system may be as follows:

Computer with input/output system	$ 150,000
New instrumentation	50,000
Engineering	50,000
Total	$ 250,000

In order to understand how an investment in control of this magnitude can be justified, it is necessary to discuss the basic process control problem in some detail. Whether or not a computer is used in control of a process, a control system is necessary because of the presence of various external or independent or uncontrollable variables which tend to disturb or upset the process. In a typical process, a number of simple control loops are installed to maintain process conditions constant in the face of these external variations. However, for most economic operation of the process — that is, for operation corresponding to the best possible combination of product quality, production rate, yields, and operating costs — the set points at which these small control loops maintain critical process flows, temperatures, and pressures should be adjusted to take best advantage of the changes in external variables. Such set point adjustments are normally made by the process operator, and are based on his experience and knowledge of the process. In a computer control system, these set points are readjusted by the computer.

A wide variety of uncontrollable variables is found in the process industry, including:

Changes in raw material characteristics — chemical composition, physical characteristics, temperature, and flow rate.

Variations in ambient conditions — temperature and humidity of process air, or cooling water temperatures.

Breakdowns in process equipment, such as pumps and compressors.

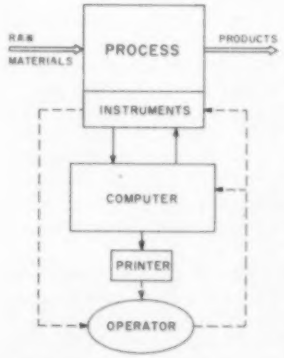


FIG. 1. Schematic computer system diagram.

Noise—surges in process vessels, variability in process instruments.

Changes in process characteristics — catalyst activity, heat-exchanger coefficients, or fractionating tower tray efficiencies.

Changes in market conditions — values of raw materials and products, or desired production rate of various products. These changes may come about either through changes in the economy of the country or, perhaps more frequently, through changes in the "market" within a

plant as intermediate storage capacity is used up or related processes are temporarily shut down.

In order to make the above discussion more meaningful, let us examine the operation of a fluid catalytic cracking unit. The control problem for a typical unit of this kind may be described roughly as follows: Adjust reactor and feed temperatures, recycle ratio, regenerator pressure, regenerator air flow, and fractionator conditions, to make a combination of products having the largest possible value in the face of fluctuations in feed quality, feed flow rate, ambient conditions, and cooling water temperature, while at the same time maintaining the reactor-regenerator heat balance and remembering limitations on compressor capacity and catalyst circulation rate. A mathematical description of this set of conflicting requirements is outlined in the next section. However, it is enough to note here that: (1) the problem of operating the unit so as to maintain the heat balance and operate within the compressor and catalyst circulation rate limitations is difficult in itself, and often absorbs the full attention of process operators in typical plants; and (2) the "best possible" operation of the unit may differ from "typical" operating conditions by as much as ten cents a barrel, and very often differs by two or three cents a barrel. This difference comes about because the effect of the independent variables on product distribution is so complex that the operator cannot be expected to operate the unit in such a way as to take advantage of it. For example, in a particular FCC unit, a change in crude which tends to make the feed more refractory is likely to cause the conversion to drop, less coke to be deposited on the catalyst, the catalyst circulation rate to decrease, and — as a result of all these changes — the product distribution to change. The proper choice of reactor temperature and recycle ratio to yield the most economically valuable spectrum of products is then a formidable problem.

For any specific fluid cracking unit, the control problem — that is, the important uncontrollable variables, the overriding process limitations, and the economic picture — is likely to differ from that described above. The value of a computer control system in any such situation must be determined by examining the pertinent uncontrollable variables for that unit, estimating their effects, and estimating the improvement in product distribution which might result from a control system able to react quickly and accurately to these variations.

Let us now go over the major problems which must be solved in planning for and installing a computer control system for a fluid catalytic cracking unit. The key steps, in the sequence in which they take place, are: development of the control equations; selection of measurement techniques and instrumentation; writing the computer program; and delivery and start-up.

Development of Control Mathematics[1, 2, 3]

Several types of equations must be used in control, some fairly easy to come by and others very difficult to derive. There must be an objective equation, which expresses the operating "profit" or return gained in running the process as a function of process conditions. There must be a series of operating relationships, which express product quality and flow rate as a function of the uncontrollable and controllable variables. And there must be a set of constraints or limitations on process operation — bottlenecks or safety factors, for example — which restrict the control system in certain ways.

In order to make clear what kind of equations are necessary, let us look in more detail at the FCC unit example. A simplified flow diagram for an FCC unit is given in Fig. 2. The feed is preheated, mixed with recycle gas oil from the main fractionator, and injected into the reactor with regenerated catalyst. Catalyst is withdrawn from the reactor,

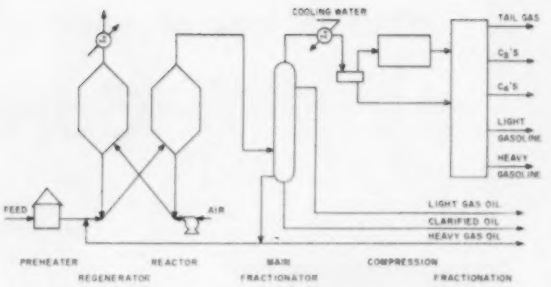


FIG. 2. Simplified flow diagram of a fluid catalytic cracking unit.

mixed with air, and blown into the regenerator, where coke is burned off. The flue gases from the regenerator make process steam, and suspended catalyst is removed before they are vented. Reactor products go to a main fractionator, where the light ends are separated from recycle gas oil, clarified oil, and light gas oil. The light ends are condensed, the gas compressed, and liquid and gas fed to another fractionating section, where C2's, C3's, C4's, and light and heavy catalytic gasoline are separated.

With this process picture in mind, let us list the uncontrollable variables. For a unit of this kind they might be . . .

Feed composition, varying with crude characteristics.

Feed flow rate, determined by the action of the crude still on varying crude.

Ambient temperature, as it affects: heat losses from reactor and regenerator; and weight of air fed to the regenerator.

Cooling water temperature, as it affects the weight of gases compressed in final fractionation.

The effects of these variables can be balanced by certain actions taken by the control system. The selection of a proper set of controllable variables is very important, and may include:

- Feed temperature
- Reactor temperature
- Regenerator pressure
- Recycle flow rate
- Air flow to regenerator
- Main fractionator temperature and pressure

Some key variables, such as reactor pressure, regenerator temperature, and catalyst flow rate, are used by the existing control system to exercise control over others. For example, regenerator catalyst flow is often used to hold reactor temperature at a pre-set value through the use of a conventional two-term controller. The computer-control system will determine what this pre-set value should be. Other key variables, such as operating conditions in the final fractionators, are omitted for simplicity.

We can now write the objective equation:

Operating return = value of products − cost of crude − catalyst cost − utility cost . . . . . (1)

Here "value of products" is the sum of a number of terms of the form (flow rate of product) (value of that product). For a typical FCC unit, the product values may be

Table I

Tail gas	$ 2.00/bbl
Propane-propylene	3.20/bbl
Butane-butylene	3.75/bbl
Cat gasoline	4.40/bbl
Gas-oils	3.40/bbl
Clarified oil	2.50/bbl

for a feed value of $3.60 per bbl. The purpose of any control system is to adjust these various product flows (by making adjustments in the controllable variables listed

above) to maintain the total operating return of Equation (1) at a maximum value in the face of changes in the uncontrollable variables.

Process relationships are generally the most difficult equations to derive. Because the reactor-regenerator system determines the basic distribution of products from the unit, equations describing this system are most important. These equations must include

1. **Heat balances** for reactor and regenerator, relating the heat liberated in the regenerator (and hence air flow, catalyst flow, flue gas flow, etc.) to heat used up in the reactor (and hence to feed flow, feed temperature, etc.), and including heat losses through radiation.
2. **Yield equations** for the reaction. The reactor-regenerator system breaks down the raw feed into the variety of products whose values are given in Table 1. The proportion of each of these products in the reactor top gases must be expressed as a function of raw feed characteristics and flow rate, reactor (and regenerator, if necessary) operating conditions, catalyst activity, and any other pertinent variables.
3. **Material balances** for various process units, including total flows but also including, for the fractionating systems, equations balancing the flow rates of various components.
4. **Distillation equations** for fractionating towers, relating the take-off rate of the several product streams to tower operating conditions and to feed rate and composition.

The heat and material balances will, in general, not be very difficult to derive. The yield and distillation equations, on the other hand, may be very difficult to find. Typically, in a complicated process like this one, yield and other similar equations are derived using a combination of analytical and statistical techniques. First, a theoretical analysis of the process is attempted with the object of formulating as accurate as possible a mathematical description of the chemical reactions taking place. This mathematical formulation is based on the kinetic equations describing the reaction, and these differential equations must be integrated to obtain product yields as a function of reactor conditions. Although this analytical approach is exceedingly valuable and generally indicates the form which the yield equations must take, it is almost invariably and necessarily oversimplified and must be supplemented by the application of statistical techniques. As much data as possible must be collected about the process — from log sheets, pilot plant runs, and studies of similar units. This data is then examined in detail, in order to eliminate inconsistencies and to select data covering as wide as possible a range of operating conditions. This information, taken together with the analytical results, can be used to derive a set of equations which describe process operation with fair accuracy.

The last class of equations — the constraints or limitations or process operations – are usually very easy to define. For the FCC unit of Fig. 2, they might include maximum pressures for regenerator and reactor, capacity limitations on air blower and light ends compressor, maximum catalyst circulation rate, maximum capacity of feed preheater, and fractionating tower capacity limitations consistent with no tower flooding or vapor entrainment. All such limitations and restrictions must be very carefully defined, for they will of course have a substantial effect on the solution to the control equations.

When all control equations have been derived, it is necessary to decide how they should be solved by the computer. Mathematically, the problem requires the solution of a non-linear programming problem, with the objective equation as the function to be maximized, the process relationships and constraints as subsidiary limiting equations, and the controllable variables as the unknowns. No generalized method has been developed for solving equations of this kind, but for any specific set of equations it is always possible to find a solution method.

Instrumentation[4]

When the equations for control have been derived, it is necessary to determine what measuring and control instruments are necessary to implement them. The problem of choosing control instruments is generally quite simple. Usually a signal from the computer is fed to an electric to pneumatic transducer, and the resulting pneumatic signal is employed as the set point for a pneumatic controller. This arrangement has the double advantage that the computer does not have to react to minor fluctuations and noise in the process; and that conventional pneumatic instruments are present to take over control under the direction of an operator if the computer or some process instrument or instruments go out of service.

Measurement problem — the problem of obtaining accurate and timely data about the state of the process to feed into the computer — is generally much more difficult than the control problem. Many of the key process variables are of course easy to measure — flows, temperatures, pressures, and levels. Special steps must of course be taken if extreme accuracy is required, but the computer itself can help by taking frequent samples and obtaining average values, or by running automatic calibration tests at frequent intervals. Other measurement problems are much more difficult to solve. For the FCC unit control system we have been discussing, it will be necessary to obtain some measure of feed quality, and of reactor product quality. For some of these measurements, presently available instruments can be used. Feed viscosity and gravity, for example, can be continuously and reliably measured with present day instrumentation. And the chromatograph may be useful in measuring product quality. However, it is often not possible to find measuring instruments that satisfy all the requirements for control. Under these circumstances, it may be necessary to find some alternative way for getting the appropriate information into the computer. For example, it may be that a difficult-to-measure chemical property is closely related to and can be inferred from measurements taken on two or three physical properties.

Computer Programming[5, 6, 7]

With the control equations established and the instrumentation determined, the principal functions of the computer control system are fairly well defined. The computer program is a detailed statement of precisely what the computer is to do under all possible circumstances, and must be prepared with great care, checked out, and stored in the computer memory before the computer is delivered to the plant. Before the program can be written, a number of important details must be decided upon. The instruments to be used must be studied, and calibration curves established to relate the voltages which come from the instruments to physical quantities being measured. If some instruments are to be calibrated by the computer, the frequency of calibration must be established and appropriate computer signals designated which are to initiate the calibration. If some instrument signals are likely to be "noisy," the computer may be required to take a number of sample readings and average them. The sampling frequency and number of samples per average must of course be determined beforehand. If a chromatograph or some similar instrument is to be used for measuring stream quality, steps must be taken to provide a peak reading for the computer, or to find the area under such a peak for use by the computer.

Before the program can be written a number of steps must be taken to plan for communication between the process operator and the computer. It is usually desirable to give

the operator the ability to make special requests for information about the process — a special print-out of process conditions at the time the request is made, for example. It may also be necessary to have the operator insert laboratory data or other information about process or plant conditions which will affect control actions to be taken by the computer. Under these circumstances, the usual procedure is to prepare pre-punched cards containing the information to be inserted into the computer. The operator then selects an appropriate card, puts it in a card reader, and presses a button requesting that the computer read the card. The computer then reads the information from the card, prints out an acknowledgment to the operator including the time at which the card was read and a statement of what information it contains, and then proceeds to make use of the data it has received. This gives the operator a confirmation of the step he has taken, and establishes a permanent record of just what that step was.

The heart of the computer program is, of course, the control program. The calculations to be carried out here are determined as soon as the method of solution of the non-linear program problem referred to above is designated. However, the frequency with which these calculations are to be carried out must be determined before the program can be written. The required frequency will depend on the expected rate of variation of uncontrollable variables and upon the dynamics of the process involved. It may also depend upon the characteristics of measuring instruments, if periodic instruments such as chromatographs are used, or if the computer must average a number of readings taken from an instrument over a period of time.

Before the program can be written, the reliability of the entire process control system must be examined and plans made to make it fail-safe. That is to say, procedures must be set up to insure that the process continues to operate smoothly under all anticipated combinations of trouble in the computer or in process instrumentation. In writing the program, certain steps can be taken to insure that the system is fail-safe. Instrument readings can be compared with previous readings, and very large changes may be interpreted as evidence that there is instrument trouble. The computer may then print out an alarm, and then go on with its control calculations, using the last previous good reading from the instrument in question. The programmer can arrange to make the computer do all its control calculations twice before making an adjustment on the process. Finally, the computer is generally required to solve comprehensive test problems periodically, and turn control of the process over to the operator if it fails such a test repeatedly.

Installation and Start-Up

The delivery of a computer control system to the plant, signals the beginning of from four to ten weeks of intensive work installing and starting up the computer control system. This work does not, of course, interfere with normal running of the process.

The first step is to connect process instruments to the computer input system. These inputs can then be read into the computer under control of a trial program and can be printed out to test whether calibration and noise are approximately as expected. At this point it may be necessary to revise some of the constants or programs stored in the computer to accommodate unexpected signal characteristics. Next, the logging functions of the computer control system are tested. Values printed out by the computer are compared with instrument readings, and any deviations noted. The total flows, conversions, and other computed values are checked. The scanning operation is checked by inserting artificial changes into the input system to see whether the computer detects these variables as out of tolerance. In similar ways, the operator communication system and the fail-safe system are checked by imposing artificial conditions on the computer inputs and by requiring the operator to make special requests of one kind and another.

When the various non-control functions have been tested as comprehensively as possible and any inconsistencies or program errors have been eliminated, it is necessary to check the control portion of the system. This too is done in steps. First, the computer is required to perform the control calculations on the data it receives from process instruments and to print out the control adjustments it would make. These printed out adjustments can be used by the operator and compared with the adjustments he makes himself. As time goes on and he gains confidence in the computer's results, he can make these adjustments manually so that the process is being operated by the computer with a manual link. Meantime, the computer's analog outputs, which are to be used in adjusting process controllers directly, are checked to see that they correspond precisely to the results the computer is printing out. As soon as the operators have gained confidence in the computer's calculated set points, the computer's outputs may be connected directly to process instruments. This is generally done one instrument at a time, with plenty of time allowed after each connection for unexpected trouble to develop.

Although the task of connecting computer to process, and of designing and planning the computer control system itself, takes many months, the process owner should not assume that he can forget about the system after it is installed and checked out. He has made an investment in improved control, and in order to make this investment pay off — and pay off at increasingly high rates as time goes on — he must continue to improve and develop the computer control system. He should, for example, find that the improved data he has on the process and the equation-checking features he has built into the computer will provide him with information which will enable him to improve the process and to modify and thus improve the control equations. He may want to add instrumentation from time to time, and will then require new inputs to the computer and program modifications to handle these inputs. Furthermore, as time goes on the process control system should change for other reasons. There may be changes in process equipment, such as the addition of compressor capacity or fractionating tower improvements. Alternatively, the market situation may change so that the objective equation needs to be modified. For the FCC unit for example, conditions might arise under which there is no market for certain products in excess of some fixed quantities. Such a change would require extensive changes in the computer program, though the computer equipment would not change in any way. All in all, it will be necessary for a group to be assigned the responsibility for maintaining and improving process control if best possible results are to be obtained from the use of this powerful new control tool.

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★ ★ ★

Mountains of paperwork reduced by . . .

Integrated Data Processing

Ten clerks in 1935 were needed for every 100 workers; by 1950 same number of workers required 40 clerks. Computers are turning the tide.

J. W. Haslett **Paul Hodge**

Shell Oil Company, New York

MAN IS STILL on his never-ending search for new and better ways of doing things. All the way up the incline through all technological advancements, the data relating to his successes or failures has been recorded in one way or another with tablets of stone, papyrus, silk, rag paper and quill.

"Paperwork" means many things to many people — letters, contracts, reports, or statistics. Paperwork in the business sense has generally come to mean the recording, analysis, transmission and storage of information. In the business transaction facts are usually recorded for two major reasons: First, for control purposes and to help someone do his job better. Second, to meet government regulations which require the filing of income tax, social security and other information. A paper instructs the shipping department to fill and ship an order; another paper informs the control section that the product is being withdrawn from inventory; a paper directs the shipment via carrier to its destination; a paper tells the biller to render another paper which informs the customer of the amount due for the shipment. All these papers and many more help someone to fulfill his responsibilities within the business organization.

However, in evaluating the voluminous flow of paperwork in the objective of helping someone to do his or her job better, consideration must be given to cost vs benefits derived. An interesting comparison which points out the rising cost of paperwork activities can be drawn when it is realized that in the middle 1930's 10 clerks were needed for every 100 workers; by 1950 forty clerks were needed for the same number of workers. Obviously some technological advancement in the paperwork field, commensurate with that of the industrial area, had to take place to equalize this growing imbalance. Paperwork had to be less burdensome and more fruitful.

Development of machine facilities into a series of related operations toward a more comprehensive improvement in paperwork operations introduced the phrase "integrated data processing."

What is integrated data processing or IDP? In its simplest concept IDP should be considered as a means of simplifying and eliminating manual repetitive paperwork operations. In addition, it involves efficient, automatic and rapid handling and communication of business data. An IDP system includes:

- Original entry or recording of data in a mechanically reusable form.
- Generally this form is either perforated tape or punched cards.
- Communicating and processing this data in an automatic manner.
- Integrating or coordinating all the related data processing procedures.

Last point is the key difference between an integrated data processing system and other data processing operations. IDP is distinguished from any fragmentary mechanization by the feature of minimum manual interruption. It is the mechanical handling of given data without manual intervention to write, keypunch, compute or otherwise process the original data for all required purposes.

The basic principle of IDP is the automatic perpetuation of repetitive data. The use of carbon paper, in a limited sense, is a form of IDP. A certain amount of repetitive work has obviously been eliminated if more than one required copy is created with a single writing.

Some bookkeeping systems employ this principle in a modified form. The "peg-board" or "one-write" systems utilize forms arranged in a predetermined pattern, one over the other. Spot or sheet carbon is so placed to allow the automatic transfer of pertinent information from one form to another with a single writing. Data has been posted in its proper place on respective forms without requiring an employee to repeat each entry.

It is apparent though that carbon paper arrangements are inadequate to accommodate the more complex operations of transferring information. For instance, how can the customer's name and address on a sales order be transferred to a shipping order, bill of lading, invoice and related sales reports? A method must be found by which one office machine can communicate with another machine to transfer and copy automatically the name and address as well as other pertinent data. Once that has been accomplished all that remains to be done is to introduce the source of information into the first machine correctly.

This in essence is IDP, the mechanical reuse of verified source information in its proper sequence to record mechanically the complete transaction, creating automatically the required accounting documents and storing the data in a form which can be translated to a common language for further compiling, calculation and analysis.

In developing an IDP system, it became necessary to find a common language for the many different types of machines used in the recording of data. Each of them has its own "native language." The typewriter responds to the depression of one of its keys; punched card accounting machines will respond to the presence of a punched hole in a card. The key stroke is the native language of the typewriter and the punched hole is the native language of the punched card equipment. Neither of these machines can communicate with the other in its native language.

However, by utilization of a common language, it is practical to incorporate many machines into a basic business system without resorting to translation from one language to another.

Common language for IDP systems today is the Baudot 5-channel punched communications tape or edge-punched cards. The tape is 11/16 in. in width with 5 rows or channels along its length. A combination of holes punched across the width of the tape forms a code which represents alphabetic or numeric characters. The tape offers thirty-two code or hole combinations which are enough for the alphabet, and when used in conjunction with a shift code, provides for numbers, punctuation, fractions and certain functional codes for instructing the machines as to what they are supposed to do.

A good illustration of the operation of the common language function is the manual transmission of teletypewriter messages. In direct keyboard transmission the sending of code pulses over the signal line is manually controlled. The operator strikes a key, code pulses travel over the signal line and the character is typed at one or more distant points. But there is an automatic method of sending code pulses over a signal line. This is the method concerned in IDP. The keyboard and line transmission are separated so that each can be controlled individually. The keyboarding or recording is done on an automatic send/receive machine which, instead of transmitting the pulses over the signal line, punches holes in a paper tape. This coded tape is then fed into a transmitter distributor unit, which senses the code holes in the tape, makes electrical contacts and automatically sends the pulses over the line. At the receiving point these code signals are translated into either printed copy or punched tape or both. This new tape may be fed into a tape-to-card converter which translates the information to punched card form. The punched cards may eventually be used as an input medium to a computer. Of course the reverse of this operation is just as practical. Information in punched cards can be converted to tape for rapid, automatic transmission to distant receiving points. Thus the common-language tape affords great flexibility in the mechanical introduction of pre-recorded information into the IDP system.

As to the business machines which are compatible to an IDP system:

Wire Communications Machines

. . . Are available from different sources. They are capable of both sending and receiving messages by wire and of being operated manually or automatically. Combinations of wire communication units may be arranged in such a way that they may produce punched paper tapes as well as being operated by punched paper tapes.

Typewriters and Teletypewriters

. . . Write copy and simultaneously generate punched tapes.

Adding Machines or Adding Calculators

. . . Are capable of producing punched paper tapes as automatic by-products of their normal operation.

Tape-to-Card Converters

. . . Are capable of translating five-channel tape to punched cards which may then be used in conventional accounting machines.

Card-to-Tape Units

. . . Translate punched cards to the punched tape medium.

The electronic computer, many times used as an integral unit of IDP, may also be considered as a member of the common language family. Business data which exists in the form of punched paper tapes may be introduced into computer units with the use of converters, if necessary, or directly if the computer is so designed.

Any or all of these types of machines may be utilized in an IDP system. The type and number of machines in the system is dependent upon the specific application.

A typical application of IDP concerns the distribution and sale of petroleum products. For simplicity the problem will be confined to four basic operations: (1) ordering; (2) shipping; (3) billing; (4) consolidation and interpretation of data.

Sales transaction data consists of both fixed and variable information. The fixed data incorporated in a customer master tape includes: remittance address; carrier and routing; type of carrier; shipping origin and identifying codes; origin state code; type of transaction code; customer or destination plant number; FOB point; controlling division; consignee name and address. The product master tape includes: the product name and numbers, I.C.C. shipping description, type and size of container and package code.

Variable transaction data includes: reference number; shipping date; customer order number; railroad tank car or truck number; quantity; price and extensions.

The sales order originates through the customers' contact personally, by mail or by telephone with either a salesman or the ordering location. At the ordering office the customer master tape is selected from file and fed into a teletype send/receive machine. A prefix code in the master tape turns on the receiving machine at the applicable shipping point. This operation automatically writes the shipping order, with manual insertion of variable data only at programmed machine stops. The receiving point (shipping origin) receives not only the requisite copies of the shipping order, but also a by-product tape for subsequent use in bill of lading and invoice writing and eventual creation of punched card media.

Once the order is ready to ship, the shipping order by-product tape is used to write the bill of lading. At programmed machine stops the operator inserts the variable shipping data consisting of date, quantity shipped, truck number and any other pertinent variable shipping information. At the same time this information is being transmitted to the controlling office to produce a bill of lading and invoicing by-product tape.

The bill of lading by-product tape later will be converted to cards for stock shipping control. The invoicing by-product tape will be used to write the invoice and for subsequent generation of sales cards, journal item cards and account receivable cards.

Thus, complete transaction data and the required forms have been produced from a single verified source document, the master tape. It is now possible to summarize the data to meet the related sales, operating and financial reporting requirements. This is a basic application of IDP to a specific problem.

There are, however, further possible products to be obtained from the more sophisticated unit of the system, as the computer.

Computers have been effective as business data processing instruments since 1954. During that time there has been a tremendous change in the philosophy of the use of the computer. Initially, almost all of the computer applications were directed toward a single application usage. Public utilities put their accounts receivable and customer billing problem on computers. Insurance companies put their premium accounting on computers. Both of these were good applications by reason of large volume. Today, however, more and more of the newer installations are directed toward an integrated approach.

The computer and the integrated system act as an adhesive and coordinator, tending to cement related internal functions together. As data from many departments is stored inside of the machine and decisions are exercised as the result of the output data, the impact of integrated data processing begins to be realized. Changes are offered in the decision-making environment of management. More data is available. The data is more precise and up to date.

The results of decisions are measurable, permitting management to pin point the effects of decisions. More emphasis is placed on data utilization than heretofore.

Transaction and statistical data is communicated to the computer by periferal IDP equipment. The heart of the system receives the information; sorts and calculates; stores; compares; consolidates and analyzes; and pumps back vital summarized facts for management interpretation and decision making.

There are nine key operations. Business generally has each one of them in some degree. They are: buying; receiving; stockkeeping; production; selling; delivery; billing; collecting; and disbursing. The first objective is to automate and integrate all of these key functions. Every key operation is related directly or indirectly to every other key operation. The system should be designed to recognize this relationship, expediting the flow of data between key operations, to provide complete information for subsequent key functions, and to serve as many of them as practical with a single input of common information.

One known application involves a fully automated purchasing procedure. All of the raw material records have been stored inside the computer. Maximum, minimum and crash-order levels have been calculated and placed in the memory. Information has been introduced indicating which are the preferred vendors, prices, terms, quoted delivery dates, and other use data. The computer starts to search and finds that something has gone below a minimum level. The computer writes an order for the vendor. But before it writes this order it checks what other items are also purchased from the same vendor and if it finds an item which is bought from this same vendor at the "can order" level the computer makes up an order for that particular item and so on until it has bought the maximum order for quantity discount purposes. When the computer decides that the order is complete it writes the order to the vendor. It selects the vendor based upon whether this is a preferred vendor or not; whether this is the best available delivery date; whether this is an acceptable price or the best price; and many other conditions. Ten days before the delivery date, the computer writes a letter to the vendor asking whether or not the delivery date will be met. When the material is received, the receiving records go into the computer. They are checked with the order, added to the inventory, confirmed with the invoice and if everything is in order the check is written in accordance with discount terms.

First day the computer was put into operation on this problem, startling results were obtained. Over 2000 orders for vendors came flying out. The first reaction was that something was wrong. Upon investigation, the computer was found to be absolutely right. Manual policing of the records had missed many reorder points which had previously been the cause of numerous crash-orders. The computer finally got them into a reasonable inventory position, eliminating a great deal of paperwork and shifting much of the clerical requirements. It left the purchasing men with time for dealing with salesmen and negotiating for contracts without the fetters of tedious paperwork.

Inventory control and related work are major areas for computer application. Industries have a substantial part of their working capital invested in some form of inventory, raw materials, goods in process or finished products. Sound management of inventories is essential under the present-day trend of narrow profit margins and rapidly changing market conditions. Decisions affecting inventory must be based on the evaluation of facts from timely reports presented to management. Inventory control and accounting for material through automation provide the necessary data on a day-to-day basis and eliminate the greater part of the risk in determining the optimum inventory for the company.

Budgeting, cost analysis and responsibility accounting are fertile fields for automation. The need for such management tools is manifest when the problems facing modern day business are considered. Again, the narrow profit margin which exists between revenue and cost units and the constant threat to such margin through ever increasing costs and the press of competition, dictate the inclusion of a sound budget system as a requisite for management.

The value of a budget system is, of necessity, dependent on the availability of a system of cost analysis which gives proper consideration to the many inter-playing factors which are related to the end product. Budgeting and cost analysis are by no means new tools. But with automation avenues of knowledge can be explored which heretofore have been closed to management by reason of the excessive cost incident to manual preparation.

There are many other major areas for computer integration into the business function: production control; sales statistics; marketing analyses; forecasting and scheduling; transportation analyses; and many more, depending on the nature of the business.

There are many apparent advantages in integrated data processing. There are also some which are more hidden than apparent.

Repetitive typing eliminated: One of the prime aims of IDP is to eliminate tedious and costly clerical tasks by the automatic reproduction of data in business transactions.

Faster processing of data: Through data transmission on to pre-printed forms it is possible to begin the processing at an earlier time. IDP saves time both in the reproduction and in the transmission of information.

Accuracy: The automatic reproduction of data is far more dependable than manual reproduction.

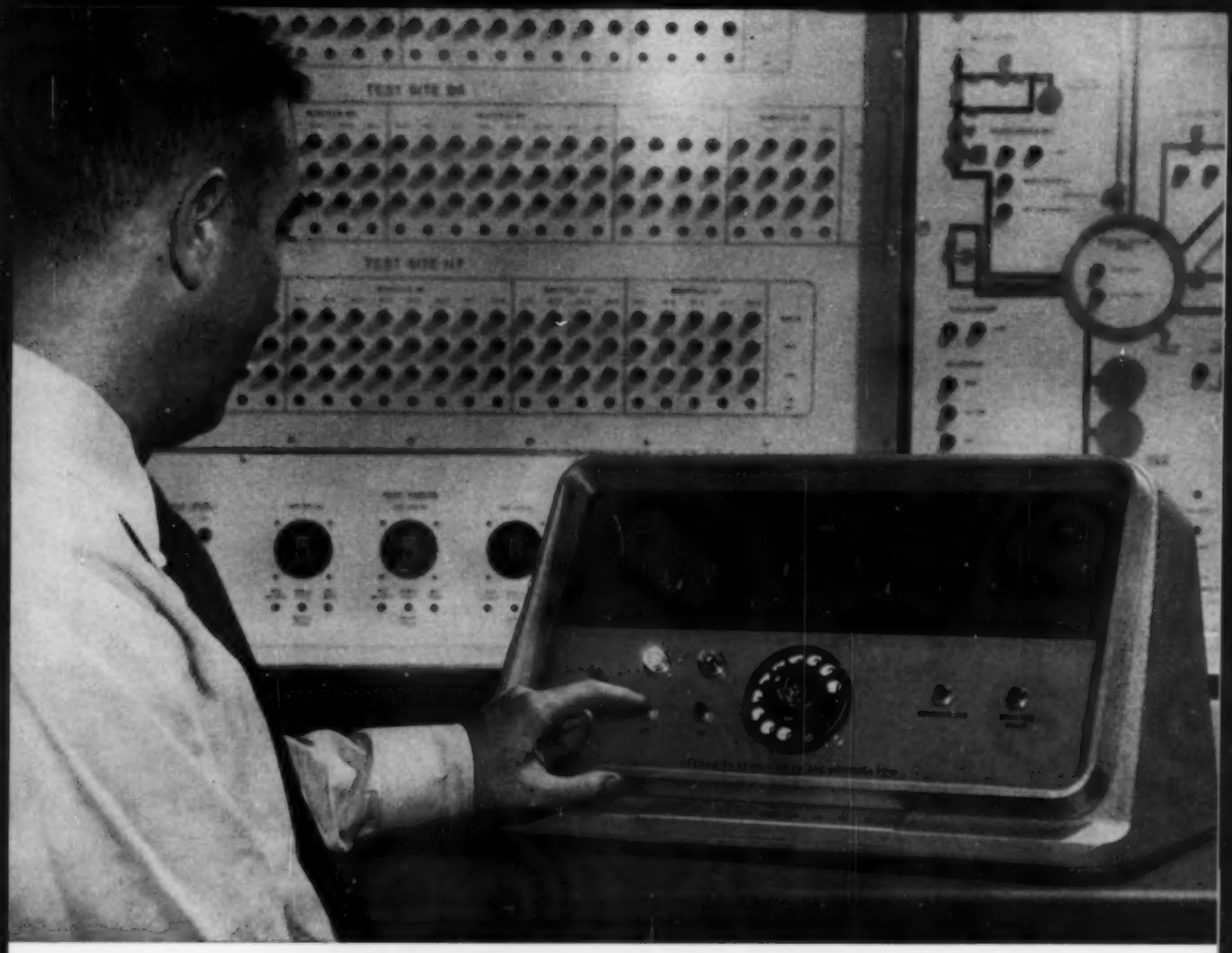
Better utilization of personnel: A basic accomplishment of an IDP procedure is to reduce the routine functions of the procedure to a mechanical and automatic function. This enhances employee morale by removing much of the drudgery related to routine manual operations. It also permits employees to apply their skills in an analytical rather than a clerical capacity.

Intermediate reports reduced: Where branch offices formerly made intermediate reports to central office for eventual consolidation, it is now feasible to transmit data directly for consolidation of the raw data, using mechanical and automatic means.

More useful management reports: Use of pre-punched tape, together with increased processing speed, makes it practical to record additional useful data at the point of origin. Hence it is possible to present reports to management that are not only more timely but also more useful in the area of decision making.

The outlook for integrated data processing is one of unlimited horizons, for the potential of complete integration of data processing has not been fully realized. The art of application of this powerful concept lags far behind the technological developments. Today, systems are in operations concerning accounting, payroll distribution, inventory, production, revenue and others, each designed to meet the requirements of the business and problems involved. IDP systems have been and will continue to be designed to meet special operational procedures, making use of different combinations of equipment. Each system may be "tailor-made." As experience is gained in the field, realization of complete integration concepts will become more apparent.

To conduct an efficient business, current summaries and reports must be made available to permit management to render the proper economic, administrative and the many other decisions required. The concept of integrated data processing offers the best vehicle now available to attain this goal. ★ ★ ★



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How you can expand the use of...

Computers in Process Research and Design

Dr. R. S. Davis,
Scientific Design Company, New York

Familiarity and understanding plus application can vastly expand seemingly limited use in chemical process research, process design and plant design

WHEN ONE IS first studying the use of computers, it is often difficult to make an adequate economic balance. This is due to the fact that people have difficulty thinking of applications for a tool they do not basically understand very well. We have found that once a computer is available in an organization the applications grow exponentially as people become attuned to thinking in terms of computers. A hidden benefit is that a much clearer understanding of a problem is required before it can be programmed for the machine. *It is amazing how an engineer's insight into a problem increases as he analyzes and programs it.* Before a problem is put on the machine the engineer must understand the problem very thoroughly. Computers may be incredibly fast but they are also incredibly stupid as far as creative thinking is concerned. They will only do what they are told to do.

All of the work described here is currently being done with a medium size digital computer system which is well suited to work of this nature due to its flexibility. In this article, we hope to illustrate the impact of computers upon process research and chemical plant design, by citing the experience of Scientific Design in this area. We will deal more in the realm of "What are we doing" than "how to do it," or "what we would like to do in the future."

COMPUTERS IN CHEMICAL PROCESS RESEARCH

In chemical process research we are frequently faced with the problem of defining a function of unknown complexity in a space which is largely undefined. For example: To explore experimentally a functional relationship,

$$Y = f(X_1, X_2, X_n; b_1, b_2, \ldots b_k), \quad (1)$$

connecting a response Y (such as yield or cost of product) with a number of variables $X_1, X_2 \ldots X_n$ (such as contact time, temperature, reactant concentration) in which $b_1, b_2 \ldots b_k$ are unknown parameters. The general experimental approach to problems of this type was first developed by Dr. G. E. P. Box, and many of the concepts which will be discussed here were first developed by him and his coworkers.[1]

Three distinct stages can be considered in investigating the above relationship:

1. **Initial study** ...would be aimed at deciding which variables affect the response. This phase would call for so-called screening studies which would delineate the important variables.
2. **Empirical study** ... of how the variables affected the response. This information could be presented in graphical form or by means of interpolation polynomials in the region concerned. Such an equation would only be an empirical representation of the function within the experimental region and would, of course, have limited usefulness for extrapolation outside the region covered.
3. **Theoretical study** ... would be made which would attempt to find a mathematical model based on fundamental principles to explain the observed experimental data. The model would attempt to explain why the response was affected by the independent variables in the manner observed. This would involve hypothesizing plausible mechanisms for the phenomena studied and estimating to satisfactory accuracy the relevant parameters.

Computers have been found to be useful in all three phases of this problem. For example, it may be necessary to know the characteristics of the function f(X,b) at least in the neighborhood of the optimum operating region for process control and design purposes. Many times in practice we will have no knowledge of the form of the function, but it is assumed to possess a unique maximum and to be smooth.

In other instances the form of the function may not be explicitly known but from fundamental considerations one might expect a set of simultaneous differential equations to have f(X,b) as their solution. If some data are available or can be generated, then the computer can be used to estimate the constants, i.e., the b's and their experimental errors, and the machine can also determine whether or not the assumed system of differential equations is adequate to explain the data.

In the first part or "screening for important variables" phase, we have found fractional factorial experiments to be quite valuable.[2] These kinds of experiments are useful where

1. very little theoretical knowledge of the system is available,
2. experimental error is likely to be large,

3. there are a large number of variables to be studied but only a few are thought to be really important, and
4. only a limited number of runs can be made.

We have devised computer programs which will design experiments for situations of this type and which also interpret the experimental data obtained in such a way that new experiments are designed.

The computer is programmed to calculate values of likelihood or "significance" associated with a wide range of possibilities. It will also transform the data and see if certain transformations give a better fit to the data than the variables originally used. For instance, in a chemical reaction the rate is usually expressed as

$$R = k_o e^{-E/RT} p_1^a p_2^b \quad . \quad . \quad . \quad . \quad . \quad (2)$$

This is a very nonlinear model. However if a logarithmetic transformation is employed we obtain

$$\ln R = \ln K_o - (E/RT) + a \ln p_1 + b \ln p_2$$

which is essentially a linear model. Hence, by this transformation one can use the computer to estimate the coefficients from the experimental data by the method of least squares . . . Since the above equation is equivalent to a first order model with

$$Y_1 = b_o + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 \quad . \quad . \quad (3)$$

where $Y_1 = \ln R$
$b_o = \ln k_o$
$b_1 = -E/R$, the Arrhenius activation energy
$b_2 = a$
$b_3 = b$
$X_1 = 1/T$
$X_2 = \ln p_1$
$X_3 = \ln p_2$

A program is available to estimate these coefficients as well as to test for their significance.

After the initial experiments are performed, the computer gives various interpretations of the data along with estimates of their degree of plausibility. Based on this analysis it might be found that some variables appear to be redundant and can be omitted. The computer will then design a new series of experiments based on the experimenter's interpretation of the computer results.

Having screened for the major variables the second phase of the problem is now entered: Empirical surface study. In this phase we are interested in finding the optimum process conditions and in describing the behavior of the response function in this optimal region. For this purpose the Box-Hunter[3] central composite designs have been found to be quite useful as they permit one to determine the curvature of the response surface in the region of interest. A useful type model for this purpose is a second order polynomial which in two variables is

$$Y = b_o + b_1X_1 + b_2X_2 + b_{11}X_1^2 + b_{22}X_2^2 + b_{12}X_1X_2 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (4)$$

The computer is of particular value in this second order stage of experimentation. For n variables there are $(n + 1)(n + 2)/2$ constants to be estimated in the second order approximating polynomial, i.e., 10 constants for 3 variables, 15 constants for 4 variables and 21 constants for 5 variables. Application of the method of least squares thus generates $(n + 1)(n + 2)/2$ linear equations in the same number of unknowns, the solutions of which are the required coefficients b_o, b_1, etc. The computer also estimates the following items:

1. How well the mathematical model "fits" the experimental data
2. The significance of each of the coefficients of the model
3. The experimental error or standard deviation of the results.

Hence, the machine takes a tremendous burden off the experimenter in analyzing the experimental results.

The machine will also look at transformations of the original data as mentioned previously. Once the surface is defined adequately in the neighborhood of the optimum, proceed to phase three.

In phase three the attempt is to gain some insight into the fundamental mechanism of the system. In phases one and two we were more or less considering our experimental system as a "black box" with certain dials which can be manipulated to give certain results. Many investigations do not proceed to phase three for frequently all the concern is with how to make the "black box" operate rather than the "why" of its operation. However, in those cases where one desires to explore the fundamental mechanism of the system, the computer can also be quite useful. As an example, consider a chemical reaction system where

$$A + B \xrightarrow{k_1} C$$

$$C + A \xrightarrow{k_2} D \quad . \quad . \quad . \quad . \quad . \quad . \quad (5)$$

and assume that the reaction rates are represented by

$$-\frac{dB}{dt} = k_1 e^{-E_1/RT} (p_A)^{N_1} (p_B)^{N_2} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (6)$$

$$-\frac{dA}{dt} = -\frac{dB}{dt} + k_2 e^{-E_2/RT} (p_C)^{N_3} (p_A)^{N_4} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (7)$$

with boundary conditions:

at $t = 0$

$p_A = p_{Ao}$; $p_B = p_{Bo}$; $p_C = 0$; $p_D = 0$

It is thus required to estimate the constants k_1, k_2, E_1, E_2, N_1, N_2, N_3, N_4 from the experimental data. A program has been devised for carrying out these computations. Actually the computer converges on the proper solution by performing a series of designed experiments. The convergence criteria is that the sum of squares of the residuals between the observed and predicted values shall be a minimum. In this case use the method of steepest descents as proposed by Booth.[4] The computer thus assumes values of the coefficients and then integrates the equations. The observed values versus predicted are compared and the machine then assumes new values of the constants, etc., until a certain preset tolerance has been achieved for the residual sum of squares between predicted and observed values.

Thus the computer can be extremely useful in various phases of research and development. This covers the initial screening phases through to studies of the fundamental mechanism of the system. New techniques are constantly being developed to speed up the convergence process. These utilize a combination of special types of designed experiments, in conjunction with computer interpretation and evaluation of the experimental results.

COMPUTERS IN CHEMICAL PROCESS DESIGN

The computer is also found to be invaluable in process design work. Much time has been saved in process material balances for complex systems having recycle. Currently all

of our ethylene oxide process material balances are done on the machine as well as the reactor design and stripper-absorber calculations for the system. This is a 7-component system with two recycle streams; hence, the material balance calculations are quite involved. The computer gives a complete balance and permits the study of many process alternates and their economic evaluation.

Actually in process work the computer does not reduce manpower particularly. However, it does permit study of many more alternates than previously with the result being that a more optimum process is achieved in the time available. One of the main benefits of computers in process design work is in making advanced technology available to the working engineer. It is now possible to program the more exact design methods and do away with the so-called "quickie" short cut methods. Thus the process engineer is able to get more accurate designs in less time without doing the tedious detailed calculations. Hence, by means of a program, he has the best thinking of the unit operations specialist and fundamental chemical engineer available to him. Currently there are programs in operation for process design of multicomponent distillation systems, fixed-bed non-isothermal chemical reactors, optimum stripper-absorber design, and flash calculations, to mention a few.

Presently a working accent is on putting cost information on the machine to optimize the various unit operations on a capital and operating cost basis. Chemical plants are sufficiently complex and differ enough so that it doesn't seem practical to program each process separately for optimization purposes. Instead, we are working toward optimizing the various unit operations taking into account such things as local utilities costs and the capital required in order to give the most economically optimum combination of unit operations. This approach permits coverage of more ground with less programming. It also permits the experienced engineer to exercise his judgment at each stage, which is something that one can't program into a machine. This system works better than trying to program the complete plant because even on duplicate jobs things are always enough different that the original program is usually not adequate.

COMPUTERS IN CHEMICAL PLANT DESIGN

Perhaps one of the most fruitful areas for computer use is in the field of detailed plant design. The machine is very valuable in such things as optimum heat exchanger design. We have a generalized heat exchanger design program which saves substantial engineering manhours. Another area is that of pipe stress analysis. This program computes anchor reactions and moments as well as combined stresses at intermediate points in multi-anchor piping systems. Such things as heat exchanger and reactor mechanical designs are also done on the machine as well as tube layout studies and tube sheet design. Stress analysis and mechanical design of towers and vessels is another area of computer usage.

It has been found that as our experience in the computer field grows new areas and applications are constantly being developed. There is confidence that in a few years computers will revolutionize the engineering business as it has done today.

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★ ★ ★

"A New Generation Of Computers"

Atlantic Refining Company announced that it will install one of the nation's newest electronic computers in its refinery headquarters.

The transistorized equipment will provide the company with new levels of data processing power for a variety of purposes—from maintaining control of over 30,000 material and supply items to mathematically simulating the refinery's operation for experimentation. This computer system will be the first of its kind in an eastern refinery when it goes into operation at the firm's Philadelphia plant, early in 1961.

T. F. Bradshaw, Atlantic's vice president of finance and accounting, said the company's objective in ordering the new computer is to make possible complete integration of manufacturing operations with accounting and statistical reporting. The Philadelphia refinery already is one of the most completely integrated in the industry, producing products ranging from waxes and lubricants to jet fuels.

The computer, which Atlantic has ordered, represents a new generation of computers, relying on transistors and advanced design for high speed and reliability. It is capable of adding 16,600 five-digit numbers or performing 27,700 logical operations in a second. Magnetic tape units will be able to feed information into the computer at the rate of 41,500 characters a second.

The new computer will be used for a broad range of work:

. . . Payroll and labor distribution.

. . . Material and supplies inventory control. It will keep track of 30,000 items, from tiny gaskets to large valves (taller than a man), all of which are vital to operation of a refinery. When stock levels reach predetermined low levels, the computer will automatically issue reports indicating the need to replenish the supply.

. . . Centralized control of packaged products. This application will aid Atlantic in developing accurate requirements statistics for efficient filling plant operations.

. . . Scheduling of maintenance work, required to keep the refinery operating effectively.

. . . Technical computing. This will include research, from statistical analyses of plant operations to crude product analysis. Gasoline blending will be guided by data derived from the computer. The system also will make possible simulation in which a mathematical model is created to accurately describe a refinery unit, enabling Atlantic engineers to experiment with it without building the real thing.

Bradshaw said installation of the large computer at the refinery will be part of Atlantic's continuing modernization of its already extensive data processing facilities.

Quarter scale model of experimental gas turbine being developed by Cooper Bessemer and Pratt & Whitney Aircraft. Units should be available for use within 18 months.

How Cooper-Bessemer is teaming up with Pratt & Whitney Aircraft to develop JET TURBINE POWER for industry

The cutaway model shown is a revolutionary new concept in gas turbines. The generating unit is a new Pratt & Whitney Aircraft jet engine – a modification of the famous J-57 aircraft engine, designed for gas fuel. The companion power unit is a new Cooper-Bessemer power turbine. This combination, now in the advanced experimental stages, represents the hottest development in industrial power in 20 years. It will mean drastic economies in installations of engine-driven compressors, generators and other rotating machinery.

For example, it is expected to materially reduce the construction cost of gas compressor stations.

Plans call for this new gas turbine to be available for broad application within 18 months. In the meantime, watch for reports on further developments in this pioneering teamwork by Cooper-Bessemer and Pratt & Whitney Aircraft.

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Special purpose automatic programming works best in . . .

REACTOR AND CRACKING FURNACE DESIGN

Speed and flexibility influence selection between general and special purpose programming of analog computers

J. R. Cobb
Phillips Petroleum Company
Bartlesville, Oklahoma

COMPUTER CALCULATIONS are accepted now as an integral part of all engineering and research work. The value of the calculations is obvious. But the problem is to devise programs that will allow the computer to be casually used on almost all engineering problems. This puts a premium on speed in obtaining answers because now a project may have to wait for the computer calculations. To solve a complicated problem with a computer three years ago was a six months or longer task. The attack on the problem was treated as a research project and if no answers could be obtained no one was really depending on the results. But now the computer is considered an integral part of the research and engineering activity. If a week elapses in running down a solution by trial and error calculations outside the computer, the delay may waste considerable man time not connected with the computing activity itself.

General Purpose Programming

One solution to this is to use the general purpose automatic programming routines that have been developed by many of the computer manufacturers. These routines are valuable, but they do not really solve the problem of speed. If experienced programmers were always available to spend from a week to two months on a special problem, and if the computer was scheduled to give maximum assistance to these special problems, general purpose automatic programming might be the answer. However, scheduling a large computer around special problems and maintaining enough programmers to have one always avilable to pick up a problem is not a particularly efficient use of the computer.

Special Purpose Programming

The best solution to the problem seems to lie in a variety of special purpose automatic programming routines; (these routines can be considered as specific programs with a number of options). Some of these programs are so flexible that almost any type of problem can be attacked with them. As the program becomes this flexible, the setting up of the data sheets becomes more and more difficult and chances for error increase. In addition, the time required to set up the problem increases. At the other end of the scale the computer programs can become highly specific, so that little or no thought is needed to use them. These programs have the obvious disadvantage of being good for only one type of problem and allow little room for the ingenuity of the design engineers.

These special purpose automatic programming routines are similar in most of their details to specific programs that have been developed in the past. The differences between the new programs and the older ones fall in three areas. One is the necessity for the program to be free from number sensitivity or limitations on range of data. Two is the necessity for the program to start with almost any set of desired conditions and proceed to whatever conditions were not specified. Three is the need for flexible output that is easily readable.

As an example of this approach to the solution of engineering problems, let's look at the use of computer calculations in reactor and furnace design. Questions in this field form a general sequence like the following. If a reaction could be made to go by means of proper conditions, would equilibrium allow the production of the desired product? If equilibrium is favorable, what are the conditions under which the reaction will proceed rapidly? If a satisfactory reaction rate is obtained, there are usually some competing reactions that must be minimized. The question thus arises, what are the general design conditions to make the reaction a profitable one? At this stage, all types of reactors can be considered, and the best choice is normally obtained if the requirements of the reaction are considered rather than trying to fit some particular reactor design. Once a particular type of reactor is chosen, the next question is what are best operating conditions to make the best product? This is seldom an easy question. In many reactions, conversion can be increased at the

expense of selectivity. High conversion usually decreases the separation or purification cost; low selectivity usually increases feedstock cost. In times of high product demand, maximum production is usually demanded even though operating expenses increase disproportionately. Markets for by-products come and go, and there is a need to know how to either minimize or maximize by-products. In some cases, the feedstock will change.

When Phillips Petroleum Company switched from a medium-sized computer to a large computer a year ago, there were several specific programs in use on reaction problems. One was used to calculate equilibrium for rocket propellants at combustion conditions, a second to simulate analog computer calculations, and a third to make a tube by tube design of light hydrocrabon cracking furnaces. All four of the questions asked in reactor problems, (a) where is the equilibrium? (b) What are the conditions under which the reaction rate is satisfactory? (c) What are the general design principles? (d) What are the specific operating conditions, need considerable experimental results along with calculations. However, by using the ideas in the rocket propellant calculation program to make a general equilibrium calculation program, revising and improving the simulated analog computer program to make basic design studies, and giving the cracking furnace program enough options to simulate operating conditions in many kinds of furnaces and reactors, valuable computing assistance could be given on almost all reaction problems.

REACTION STUDY

The first step in investigating a reaction is to find what the equilibrium concentration is. Calculation of equilibrium constants from the differences of free energy terms is not without error, but at worst these calculations show whether the reaction is feasible at all, and whether equilibrium is likely to be a factor in reaction yield.

For a simple reaction with two reactants and two products, calculation of the equilibrium constant from free energy or equivalent data is not too involved and the engineer can make hand calculations satisfactorily. To solve for the equilibrium concentration in a reaction system such as the one shown below becomes considerably more difficult.

$$C_3H_8 \rightleftarrows C_3H_6 + H_2$$
$$C_3H_8 \rightleftarrows C_2H_4 + CH_4$$
$$2C_3H_8 \rightleftarrows C_2H_6 + C_4H_{10}$$
$$C_2H_4 \rightleftarrows C_2H_2 + H_2$$

Even in simpler systems, to find the equilibrium composition of an adiabatic reactor involving only two reactions is quite time consuming. Our present program will accept up to ten different reactions and twenty different reactants and products. The reactions may be either concurrent or consecutive; they may be isothermal or adiabatic. The equilibrium constants may be calculated from free energy or enthalpy and entropy data or the constants may be supplied as input data.

The calculation procedure is relatively straightforward as summarized in the abbreviated block diagram, Fig. 1.

This calculation is similar to the ones used in calculating equilibrium in rocket propellant thrust calculations. In some high temperature reactions, equilibrium is reached. In many other reactions, the approach to equilibrium is close enough that the amount of product produced is limited by equilibrium. In all of these cases, the equilibrium calculation program will prove useful. However, in the majority of reactions with which we are concerned, reaction rates are the limiting factors in product yield. The other two programs are used in this area.

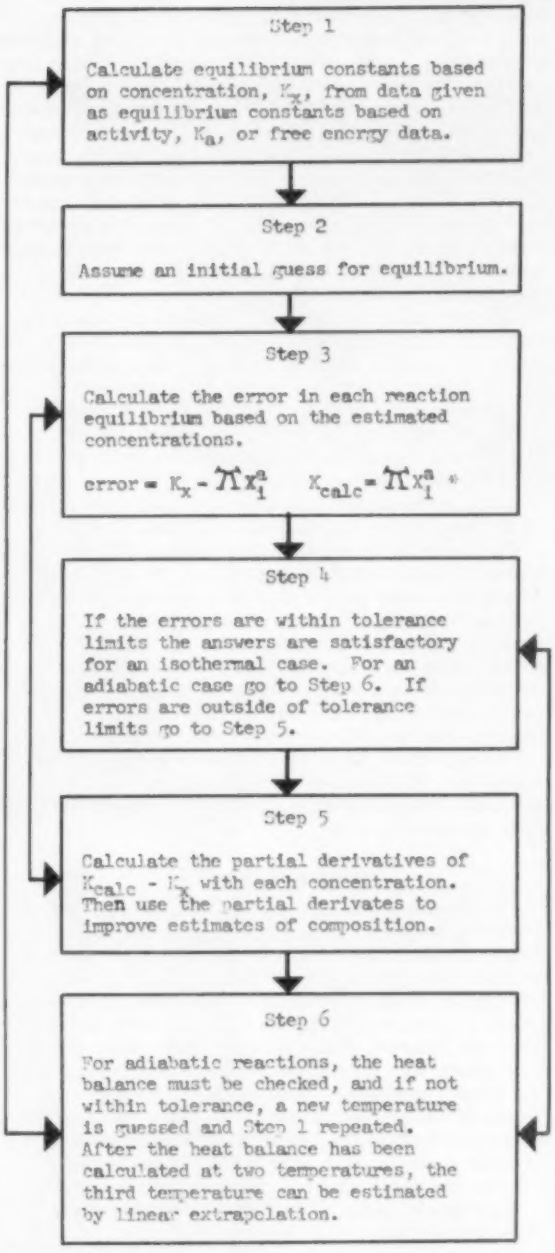
Step 1
Calculate equilibrium constants based on concentration, K_x, from data given as equilibrium constants based on activity, K_a, or free energy data.
Step 2
Assume an initial guess for equilibrium.
Step 3
Calculate the error in each reaction equilibrium based on the estimated concentrations.
error = $K_x - \Pi x_1^a$ $K_{calc} = \Pi x_1^a$ *
Step 4
If the errors are within tolerance limits the answers are satisfactory for an isothermal case. For an adiabatic case go to Step 6. If errors are outside of tolerance limits go to Step 5.
Step 5
Calculate the partial derivatives of $K_{calc} - K_x$ with each concentration. Then use the partial derivates to improve estimates of composition.
Step 6
For adiabatic reactions, the heat balance must be checked, and if not within tolerance, a new temperature is guessed and Step 1 repeated. After the heat balance has been calculated at two temperatures, the third temperature can be estimated by linear extrapolation.

FIG. 1. **Basic flow diagram** ... showing summary of calculation procedure for reaction study.

SIMULATED ANALOG COMPUTER PROGRAM

This as the name implies is a routine designed to simulate the actual operation of a general-purpose analog computer, combining the programming ease and flexibility of the analog with the accuracy and reliability of the digital computer. All of the usual components of an analog computer (amplifiers, function generators, dividers, and integrators) are programmed into the digital computer as subroutines. The data sheets can be filled out in much the same way as an analog

*This equation holds true for all components in each reaction. The exponent "a" is equal to the coefficient in the stoichiometric equation for the reaction in question, and carries a positive sign for products, a negative sign for reactants. Components which do not appear in the reaction have a zero exponent.

computer board is wired. Each operation is performed in series and the dynamic characteristic of the analog computer is replaced by a series of static calculations over short time intervals. The use of short discrete time intervals can introduce errors in the calculations. The use of the simulated analog computer program has another disadvantage in comparison with the analog computer in that an engineer cannot stand by it, changing knob settings until a solution is reached. However, along with its disadvantage, the simulated analog computer program has advantages all its own. One advantage is the ability to use eight place numbers with floating point decimal notation. This frees the program designer from the scaling work that is normally a part of the analog computer art. In some cases, the eight place numbers are valuable for improved accuracy of results. A second advantage is the ability to simulate extremely large analog computers for special problems. The present program simulates analog computers with up to a thousand amplifiers. A third advantage is the ability to use other digital programs and commands along with the simulated analog computer program. Thus, the data input can be in the form of tables or any type of equation. Non-linear equations are more easily handled by the simulated analog computer program.

The simulated analog computer program as well as the analog computer which it supplements are highly flexible. Almost any complexity of problem could be solved by this program. In effect, the program is a translation program that converts some physical phenomena into computer commands. Using this program supplied with needed kinetic and heat data, the yield in an adiabatic reactor of any given size can be determined. The effect on yield of using a series of reactors with heat transfer between each reaction chamber can be established. Since this program is completely flexible almost any variation can be calculated. As such, its use is expected to be greatest as a supplement to research work and early design work.

FURNACE DESIGN

The cracking furnace program is the last to be used on a process. It has been reported previously in more detail.[1] The present program differs little in essentials from the earlier program. Changes have been made to simplify its use on all types of cracking furnaces and reactors. Even so, the program is much less flexible than the simulated analog computer program. Many decisions on pressure drop and heat transfer are built into the program. To solve one cracking furnace problem with all of its refinements with the simulated analog computer program would require several weeks to set up, and would probably require several times as much computer time after being set up. So the choice between the two programs is flexibility versus speed.

Basic flow diagram for the cracking furnace program is shown by Fig. 2.

The new uses of this program come from the options that have been built into it which are not even shown on the simplified block diagram. For instance, the reaction area can be varied widely. The increment of reactor can have completely different dimensions for the purpose of calculating heat transfer, reaction volume and pressure drop. The reaction can be made isothermal, adiabatic, or have any desired rate of heat transfer. The program will automatically converge on either feed rate, heat transfer rate, or a temperature pattern to obtain a given conversion. The program provides for the injection of additional feed or stream at any point in the reactor. And as new reactions that require somewhat different treatment become important, the program can probably be modified within the same relatively simple framework.

In addition to these three programs, there is a definite need for a calculation method specifically designed to assist research and design engineers in the analysis of experimental data to obtain reaction rate coefficients and reaction rate mechanisms. Some results can be obtained using the simulated analog computer program or by an analog computer. However, what is needed is a program that integrates reactions over periods of time and picks the desired reaction rate constants on the basis of minimizing the difference between the calculated values and the experimental data.

These four programs should be of some assistance on any reaction problem. They are not super computer programs that take care of all problems in one gulp. At the same time, they are much faster and easier to use than trying to solve specific problems with some general automatic programming code. To be effective, they need to be understood and applied wisely. Engineers still solve engineering problems but computers can be of assistance.

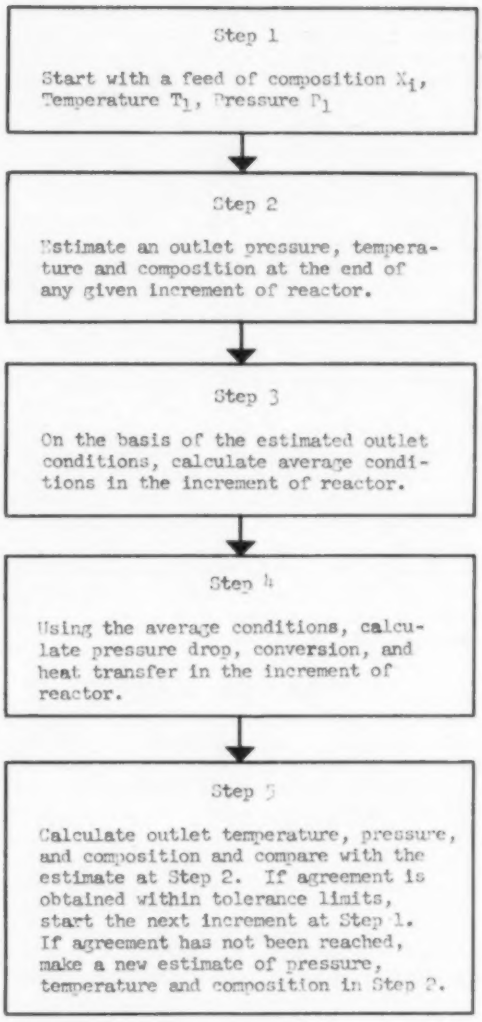
Step 1
Start with a feed of composition X_1, Temperature T_1, Pressure P_1
Step 2
Estimate an outlet pressure, temperature and composition at the end of any given increment of reactor.
Step 3
On the basis of the estimated outlet conditions, calculate average conditions in the increment of reactor.
Step 4
Using the average conditions, calculate pressure drop, conversion, and heat transfer in the increment of reactor.
Step 5
Calculate outlet temperature, pressure, and composition and compare with the estimate at Step 2. If agreement is obtained within tolerance limits, start the next increment at Step 1. If agreement has not been reached, make a new estimate of pressure, temperature and composition in Step 2.

FIG. 2. **Basic flow diagram** . . . showing summary of calculation procedure for furnace design.

Acknowledgment

The author wishes to acknowledge the work of the various engineers and mathematicians who developed these programs and who helped in their description. ★ ★ ★

[1] Andrews, A. J., Pollock, L. W. Ind. Eng. Chem. *51*, 125-128, (1959)

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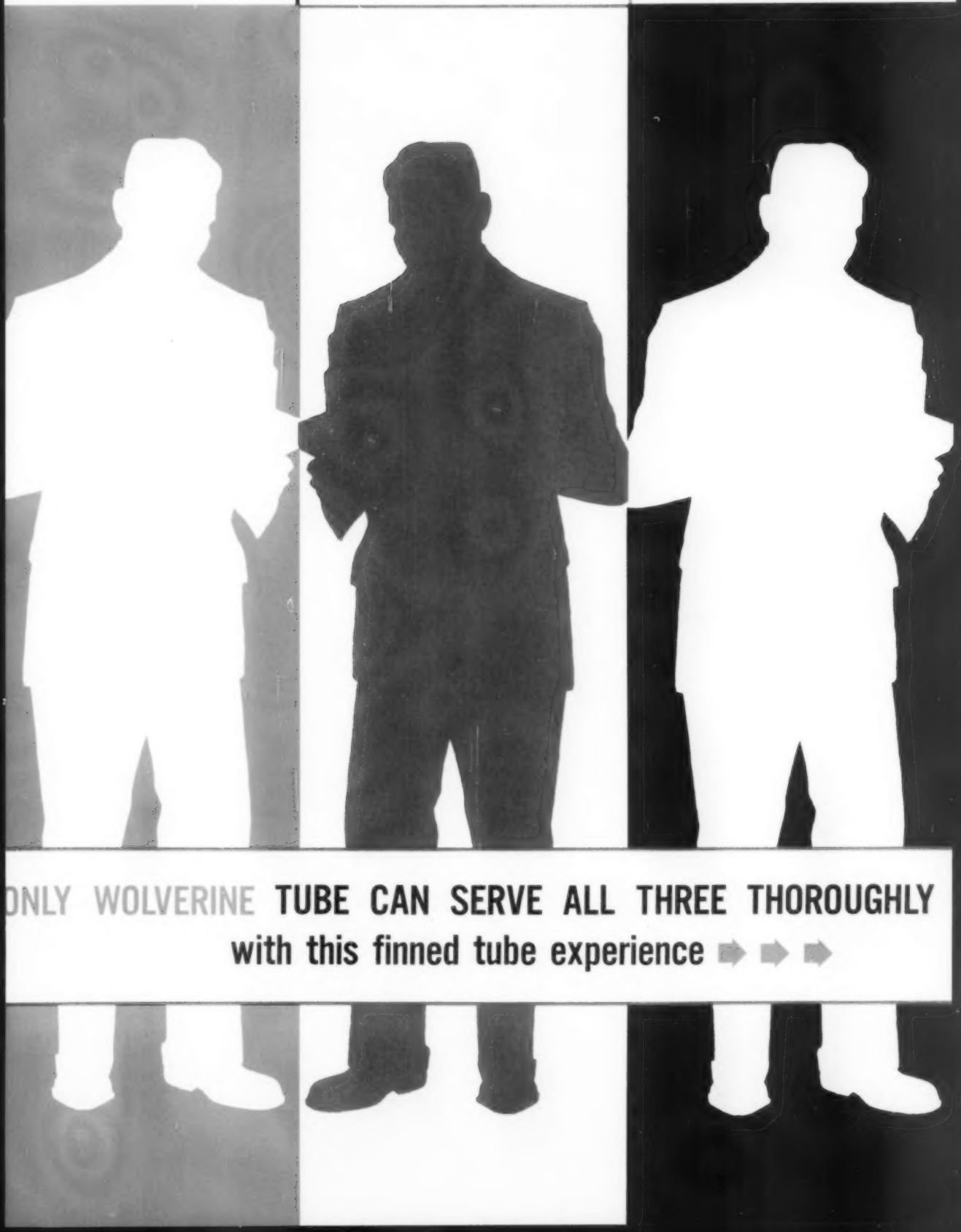

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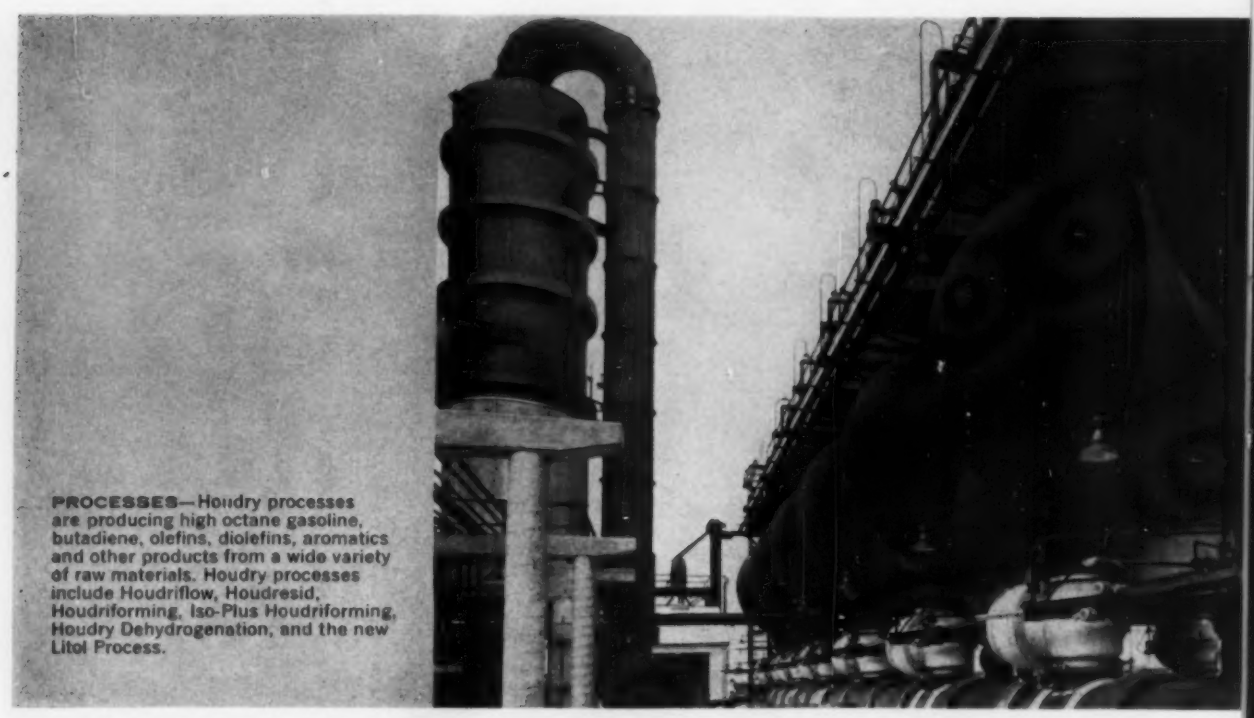

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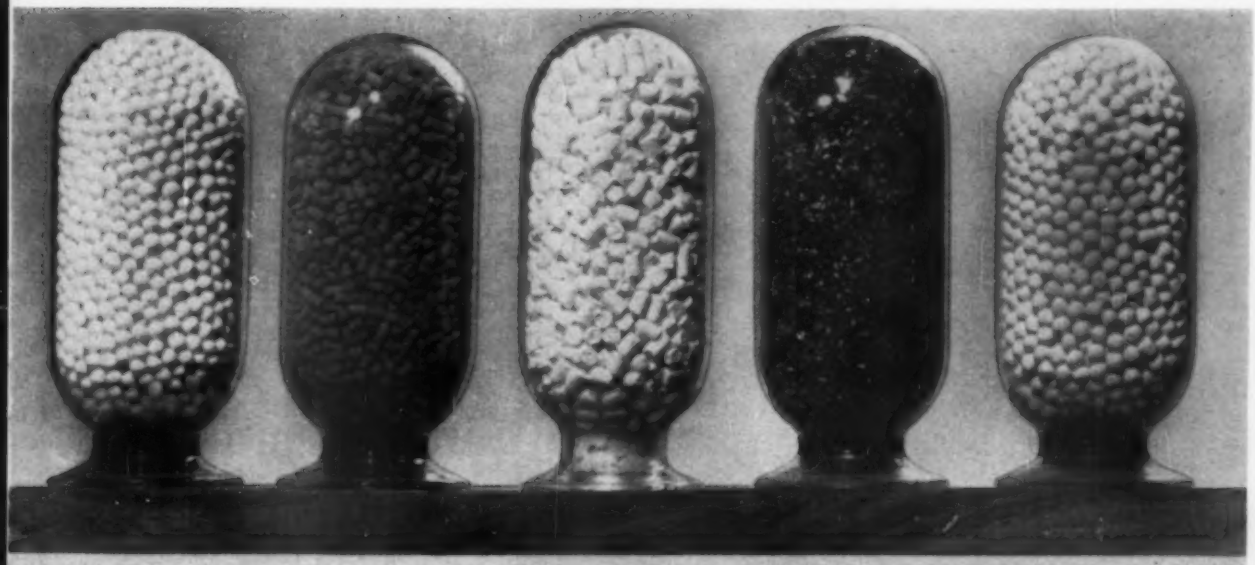

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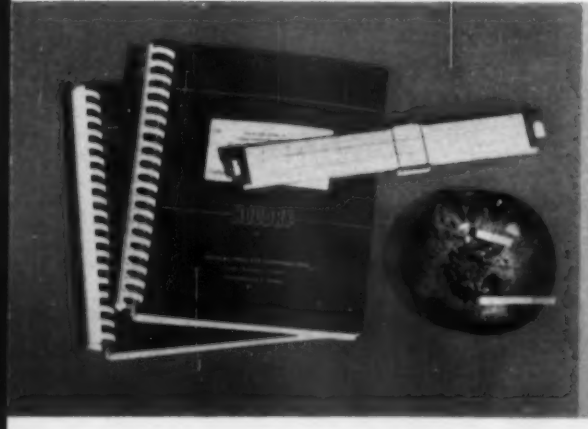

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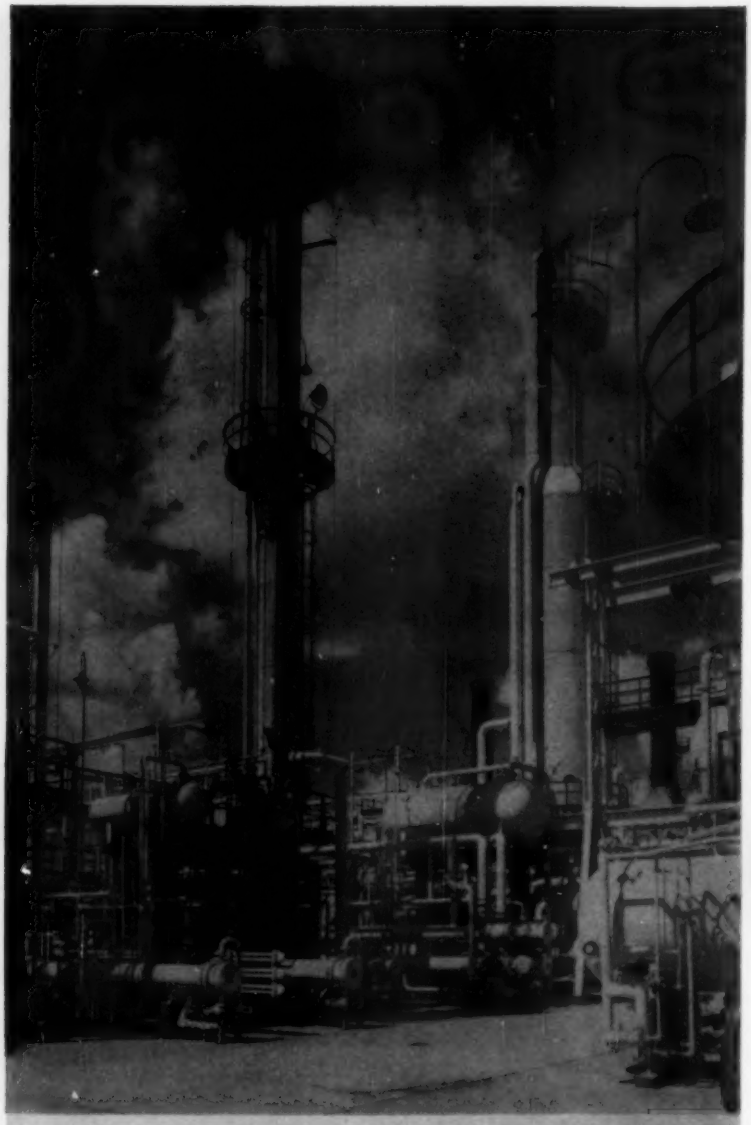


(Above) This view of Platformer LPG recovery section shows deethanizer (left) and depropanizer tower (center). Third tower (right) is Unifining Unit's stripper column.

New Platforming® unit boosts production of high-octane gasoline nearly 200%

DX Sunray upgrades product quality, boosts motor fuel production capacity, with five new UOP process units

by Harry A. Brown

Vice President of Manufacturing
DX Sunray Oil Company,
Tulsa, Oklahoma

In little more than three years after becoming the refining and marketing subsidiary of Sunray Mid-Continent Oil Co., DX Sunray Oil Co. launched a major modernization program.

Harry A. Brown

In early 1959 we placed on stream at our West Tulsa refinery a 20,000 BPSD Unifining* unit, a 12,000 BPSD Platforming unit, a 2,400 BPSD Isomerization Unit and a 2,500 BPSD HF Alkylation unit. At about the same time we added at our Duncan, Oklahoma, refinery a 6,000 BPSD Unifining* unit to an existing layout which already included a 6,000 BPSD Platforming® unit, a 22,000 BPSD Fluid Catalytic Cracking unit, a 3,500 BPSD HF Alkylation unit and a 750 BPSD Catalytic Condensation unit. Installed at a cost of $12 million, and designed and engineered by Universal Oil Products Company, our new units are the most modern available and were installed to carry out our avowed objective of marketing high-quality products.

Triples high-octane output

The four UOP units provide more high-octane gasoline than the Tulsa refinery previously manufactured. The new Platformer almost triples the output of high octane gasoline there, and addition of the new HF Alkylation unit more than doubles DX Sunray's potential for producing 105-octane gasoline. *Trademark

Being charged to the new Unifining unit is a blend of straight-run and coker naphthas for preparation as feed stock to two Platformers. These include a 7,500 BPSD reforming unit that was converted to UOP Platforming in June of 1956 and the new 12,000 BPSD unit completed this year. At relatively low cost, Unifining desulfurizes and purifies the Platforming feed stock and transforms olefins into paraffins. Combined operation with Platforming provides a most economical source for the hydrogen required in Unifining.

LPG unit recovers butane, propane

At the new Platforming unit, the Unifined, depentanized C_6-plus naphtha, or feed stock, is heated and contacted with a specially prepared platinum-containing catalyst under operating conditions to produce a C_5-plus gasoline with a leaded octane number as high as 99, if required. A rerun tower is provided for preparation of selected blending stocks. In conjunction with the Platformer there is an LPG unit designed to recover 92% butane and 60% propane.

In conjunction with the decision to modernize the Tulsa refinery, we gave careful consideration to future demands for higher-octane gasoline. Expanded facilities for alkylation, to produce motor alkylate as a blending component, were chosen since sufficient quantities of butane available in our refinery streams could be isomerized and, as isobutane, utilized as one of the feed stocks for HF Alkylation. Universal engineers, therefore, designed a 2,400 BPSD Butane Isomerization unit to service the HF Alkylation facility. The two processes are controlled and operated as a single unit.

Could produce 105-plus leaded octane

The HF Alkylation unit product is 2,500 BPSD of 105-octane gasoline blending stock. Actually, the unit would permit the Tulsa plant to turn out gasoline exceeding the 105 octane number (leaded) if market conditions should so dictate. However, DX Sunray has no immediate plans for producing motor fuels in such super ranges. If and when the need for higher-octane gasoline arises, we're ready for several years to come. Meanwhile, much of this high-octane alkylate is used to manufacture aviation gasoline. The remainder is blended with other refinery stock to produce a premium gasoline which is equal or superior in quality to any in the DX marketing area.

Combination HF Alkylation— Butane Isomerization unit assures potential production of super-octane gasoline

View of DX Sunray's Isomerization unit showing three reactors at left. Second tallest tower (center) is the debutanizer column. Deisobutanizer (right) is the highest refinery tower in Oklahoma.

UOP® UNIVERSAL OIL PRODUCTS COMPANY

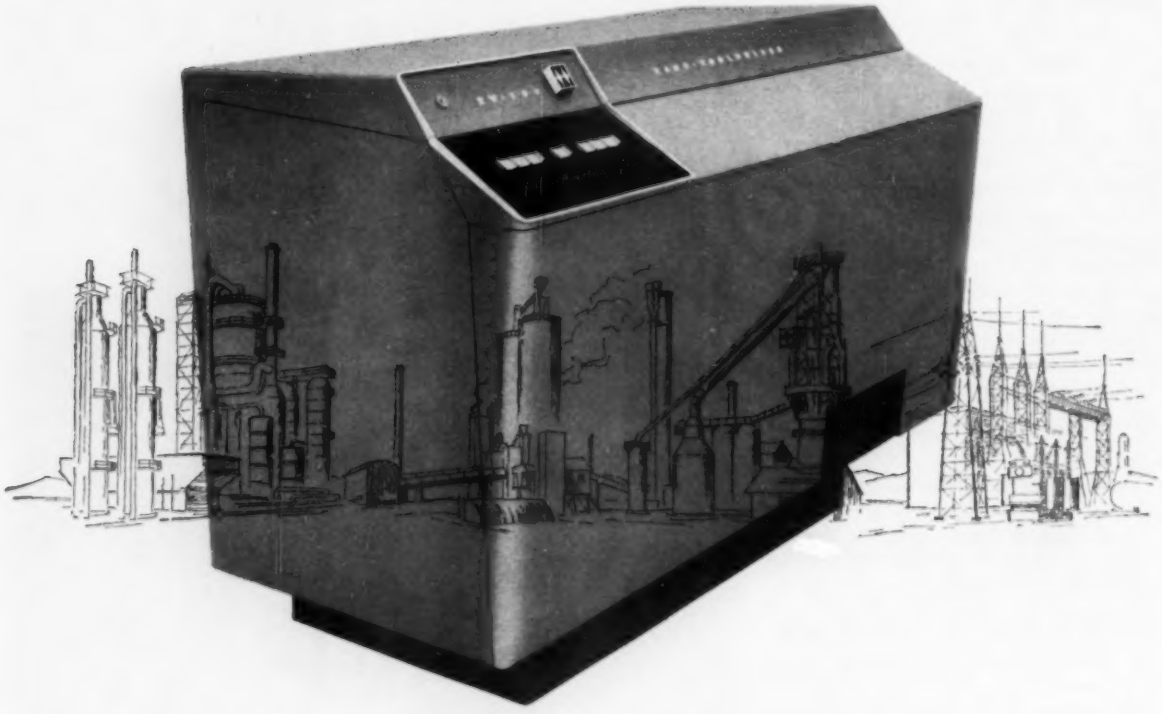
30 Algonquin Road, Des Plaines, Illinois, U.S.A.

More Than Forty Years Of Leadership In Petroleum Refining Technology

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

In a Class by Itself

FOR CLOSED-LOOP CONTROL AND AUTOMATIC DATA REDUCTION



The RW-300

DIGITAL CONTROL COMPUTER

OPERATING SYSTEMS incorporating the RW-300 for on-line control and data reduction are demonstrating these tangible benefits: *reduced costs, increased output, improved quality.*

HIGH RELIABILITY, inherent in the advanced design of the RW-300, is being proven by thousands of hours of dependable operation.

SYSTEMS ENGINEERING staff, experienced in the analysis of complex control and data reduction problems, is assisting industry with applications of the RW-300 in chemical, petroleum, steel, cement, electric power, and other fields.

NATION-WIDE SERVICE organization is providing skilled maintenance for this completely developed, production engineered, and thoroughly tested piece of *industrial* equipment.

For further information, call or write Mr. Raymond E. Jacobson, Director of Marketing, The Thompson-Ramo-Wooldridge Products Company, 202 N. Canon Dr., Beverly Hills, Calif., BRadshaw 2-8892.

THE THOMPSON-RAMO-WOOLDRIDGE PRODUCTS COMPANY

a division of ***Thompson Ramo Wooldridge Inc.***

Refining Equipment

Steel Swivel Joints

Series of stainless steels has been announced for use when handling corrosive liquids. Precision steel ball bearings and races keep joints in alignment and maintain free-turning action. Each joint has o-ring seal that prevents leakage and keeps product clean. Felt dust seal keeps lubrication on ball races. Joints are also available in other metals. *OPW Corp.*

Circle number (41) on reply card.

Electronic Computing System

Fully transistorized, general purpose digital electronic computing system which can serve both scientific and business data processing needs will be available at monthly rental of $1750, or total sales price of $87,500. This includes computer and Tape Typewriter system. No site preparation or installation costs are necessary. Deliveries scheduled for July.

Computing system is capable of operating on 9-digit numbers at rates up to 250,000 operations per minute. Magnetic drum memory section incorporates many new design features. Entire unit is encased in metal shroud to protect it from dust particles or accidental damage. Main memory is non-volatile. Switches allow information to be locked in the main memory in increments of 1024 words so it cannot be altered by program or operator error. *Royal McBee Corporation, Data Processing Division.*

Circle number (42) on reply card.

Polypropylene Pumps

Latest additions to line of fluid handling products are two polypropylene centrifugal pumps resistant to solvents,

greases, oils and many common acids and chemicals at high temperatures. Available in 2 sizes, pumps offer capacity range from 2-80 gal per min. Model No. ZP-25 has 2-30 gal per min capacity and Model No. ZP-35 has 8-80 gal per min capacity. Pumps can handle solution temperatures up to 300 F. Polypropylene casing is totally protected by cast iron frame which gives added support. *Vanton Pump & Equipment Corporation.*

Circle number (43) on reply card.

NEW LENAPE WEDGE MANWAY*
Eliminates Bolts and Yokes

This revolutionary, new manway is not only easier to open and close, but is actually more economical than conventional bolted covers. Noted for its simplicity, the Lenape Wedge Manway assembly is a unique combination of only three metal parts—ring, cover and key wedge, plus a standard gasket, and is supplied as a "package" assembly.

FAST, SIMPLE OPERATION—As illustrated, to close the manway you insert the key wedge under the cover handle and over the opposite ring wall. Then, merely tap the wedge gently with a hammer until a tight seal is secured. That's all there is to it. Troublesome bolts and yokes are completely eliminated. Uniform gasket loading is assured.

To open, you just tap out the wedge and remove the cover—all in a matter of seconds.

Write today for full details and prices on the amazing new Wedge Manway Assembly—another Lenape exclusive.

**Patent pending*

See our standard line of pressure vessel connections on pages 438-439 in the 1960 Chemical Engineering Catalog.

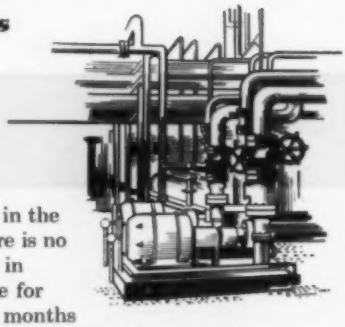
LENAPE PRESSURE VESSEL CONNECTIONS

LENAPE HYDRAULIC PRESSING & FORGING CO.
DEPT. 119 WEST CHESTER, PA.
RED MAN PRODUCTS

Positive Proof...

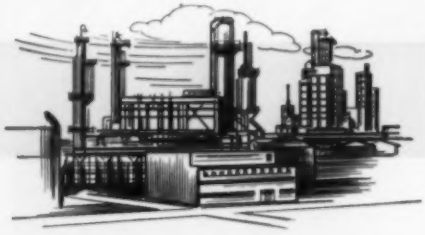
The John Crane Type 9 Shaft Seal Solves Those Tough Liquid Handling Problems

Actual Field Reports



✓ from an Arkansas Refining Plant

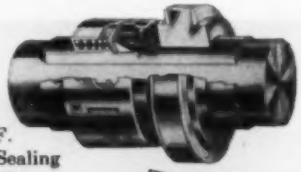
When it comes to avoiding trouble in the handling of naphtha at 420°F., there is no substitute for positive sealing. And in cases like this there is no substitute for "John Crane's" Type 9 Seal. Many months of completely satisfactory operation offers convincing proof.



✓ from a Louisiana Refinery

It takes a "lot of shaft seal" to handle a highly corrosive mixture such as an emulsion of sulphuric acid and butane. This stuff plays real havoc with metals due to its corrosive action. Despite this, Type 9 Seals on twenty seven pumps are pumping month after month in continuous service. At this same location, other Type 9's are effectively handling "fresh" sulphuric acid at the high suction pressure of 400 psi.

In cases like these . . . and in those confronting you . . . the surest answer is the "John Crane" Type 9 Seal.

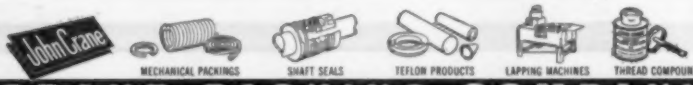


CONDENSED SPECIFICATIONS

Recommended services: all industrial chemicals, corrosives, liquids or gases. Temperatures: −120°F. to +500°F. Pressures: up to 750 psi. Construction: Sealing members of chemically inert DuPont Teflon, metallurgy best suited to service requirements.

Send us your problems. Request Bulletin S-205-2.

Crane Packing Company, 6486 Oakton Street, Morton Grove, Illinois, (Chicago Suburb).
In Canada: Crane Packing Co., Ltd., Hamilton, Ont.



CRANE PACKING COMPANY

New Equipment

Analog Computer

As solid-state computing device for mathematical calculations, newly developed CM-2 Analog Computer is reportedly finding important applications in chemical, refining and process industries. Rugged unit consists of operational amplifiers, scaling potentiometers and logarithmic networks, with convenient integral terminal board through which functions are programmed. Operational amplifiers will accept inputs from all commercially available transducers. For practical applications there is no electronic limit to number of applications which can be used, although a single Cm-2 cabinet contains maximum of 12 amplifiers, 9 scaling potentiometers and 6 logarithmic networks. *Southwestern Industrial Electronics Company.*

Circle number (44) on reply card.

Foamed Silica

. . . is a new material for insulation and refractory applications. Foamsil's acid resistance combines with its impermeability to make it ideal as lining inside tanks and pipes that contain hot acids of any concentration. Sealed silica cells in Foamsil can never absorb water or moisture so they maintain their full original insulating value throughout life of equipment they serve. In addition, it is dimensionally stable.

Fireproof material saves installation time, cost and labor because it can be easily cut to fit at close quarters. Strong and rigid, it can be used as bearing surface eliminating some of supporting structure and saving in construction costs. Its low expansion coefficient of 3.5 by 10^7 reduces expansion problem. Lightweight Foamsil means less maintenance, more production and simplifies construction. *Pittsburgh Corning Corporation.*

Circle number (45) on reply card.

General Purpose Computer

With incorporation of high-speed memory and automatic iteration capability in general purpose analog computer, new system synthesizes traditional advantages of both analog and digital computers. Analog's speed, lower cost, ease of programming, and improved output data presentation are combined with digital computer's unique capacity for data storage and time-sharing of computing elements.

Dynamic memory and storage features are also being made as optional auxiliary equipment. New system makes practicable wide range of new applications. It can solve process problems theoretically and then be applied directly to control of that process, eliminating need for costly special-purpose computers. *Computer Systems, Inc.*

Circle number (46) on reply card.

Desiccant Dryers

Availability of dynamic desiccant dryers with capacities up to 5000 std cu ft per min have been announced. Model 4000AB-EESA-8 measures 11-ft high by 11-ft long by 7½-ft deep. It is a heat-reactivated type dryer with external electric heater and purge blower. Complete line of dryers in all sizes with steam reactivation is also offered, as well as Heat-Les dryers that completely eliminate heat-reactivation and provide extremely low dewpoints and 100 percent oil removal. *Trinity Equipment Corporation.*

Circle number (47) on reply card.

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

DU PONT *Petroleum Chemicals* NEWS

Number 100 in a Series of Bulletins for the Petroleum Industry

JANUARY-FEBRUARY 1960

WHAT'S NEW IN DYES?

Du Pont Improved Free-Flowing flaked dyes provide many advantages

ADDITIVES MANAGER

W. E. BETTONEY is now serving as Manager of Additives. In this capacity he is responsible for the sale and technical services for all Du Pont additives other than tetraethyl lead.

Prior to this appointment, Mr. Bettoney served as Technical Manager for the Eastern Region. And before being named to that post, he was assistant director of the Du Pont Petroleum Laboratory.

Mr. Bettoney joined Du Pont in 1946 as an engineer in the Petroleum Laboratory. For several years he was associated with application research on the effects of chemicals on the performance of petroleum products in engines.

Mr. Bettoney is a mechanical engineering graduate of the University of Maine. Before joining Du Pont he was with the Dodge Division of the Chrysler Corporation in Chicago. Mr. Bettoney is a member of the S. A. E. and A. C. S.

Du Pont Oil Colors in flaked form occupy less space.

Du Pont oil colors have been available in either powder or flaked form for some time. Because flaked dyes are virtually dust-free, they have been constantly gaining in popularity. The newest Du Pont flaked dyes are now further improved so that they dissolve more readily than ever. As a result, more and more refiners will find that Du Pont's fast-flowing, fast-dissolving, dust-free flaked dyes are more satisfactory than ever.

Less bulk The flaked form of Du Pont Petroleum dyes takes up approximately half the space of the same dye in conventional, powdered form, thus saving refiners valuable storage space. Furthermore, flaked dyes come in short drums (22 inches high) which are easily handled.

Many colors You can get Du Pont flaked dyes in orange, red and bronze. Blue dye is available in a crystalline form which has the same advantages as flaked dyes. Samples and full details are available now from your Du Pont Petroleum Chemicals representative.

ADVERTISEMENT—Prepared for the Petroleum Chemicals Division of E. I. du Pont de Nemours & Company (Inc.)

OVER

DU PONT *Petroleum Chemicals* NEWS

New instrument for studying surface ignition

Engineers at Du Pont's Petroleum Laboratory have announced the development of a new electronic instrument for investigating surface ignition.

Used in any car

This instrument will help provide clues to both better fuels and improved high-compression power plants, since it is now possible to study surface ignition in any automobile by merely installing special pressure-sensing spark plugs in the car's engine. Surgery to the engine is eliminated.

Using a double-tracked recording tape, the new instrument determines the exact time in the cycle when the combustion pressure reaches its peak. Such information is developed for each cylinder.

Transducer at work

Heart of the electronic instrument is a special normal-sized spark plug equipped with a built-in miniature piezoelectric pressure transducer. These plugs can be substituted for standard plugs in most cars.

Variability of the instrument is less than plus or minus one-tenth of a crank-angle degree, or about five millionths of a second at 3200 engine revolutions per minute.

If you would like to know more about the instrumentation and what's been learned through it, write for a copy of "Surface Ignition—A New Look with a New Instrument."

How to keep copper from making trouble

Copper-bearing surfaces can exert a harmful pro-oxidant effect on petroleum products. In helping overcome this, Du Pont Metal Deactivator chelates with copper ions and thus essentially removes them from the reaction.

Another Du Pont product, Du Pont Metal Suppressor, reduces the possibility of copper catalyzed reactions by forming a film on the copper surface which insulates the metal from the petroleum product. Thus, copper strips which have been exposed to Du Pont Metal Suppressor are passive for some time after—even when contacted by products that do not contain the compound. Du Pont Metal Suppressor also works on brass and monel.

CONTINUED *What's new in dyes?*

Du Pont Oil Red A is announced

The most recent addition to the line of Du Pont dyes made expressly for the petroleum industry is Du Pont Oil Red A.

This is an oil-soluble dye for use with gasoline and other petroleum products. It imparts a slightly different shade to gasoline which is generally considered to be 10 to 25 per cent stronger, depending on test procedure used, than conventional reds, such as Du Pont Oil Red.

Two forms Standard packages contain 100 lbs. net. You can get Du Pont Oil Red A in powdered form, shipped in non-returnable 41-gallon fiber drums. Flaked Oil Red A comes in the 24-gallon drum.

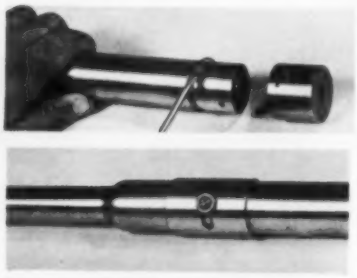
For more information, contact the office nearest you. Please see the listing below.

Modified Du Pont Dry-Dye Eduction probe offers many advantages

Until a few years ago, the dry-eduction method of handling dyes was little used. Equipment was not very efficient. Clogging, as well as other difficulties, was an ever-present problem.

Then in 1956, Du Pont introduced the "tube-within-a-tube" design. So successful was this probe that it soon became the most popular dye-handling tool in the industry.

New brass tip Now, after several years of experience, further refinements in the Du Pont design have been made. For example, brass is now used in the tip for increased durability. And the tip can be easily removed merely by flexing the securing clip with a screwdriver.



Improved air inlet The other major change is an improved air inlet which provides for a continuous flow of air as well as for easy setting of the air port to fit individual needs.

This model probe is known as No. WT-503 Du Pont Dye Probe. Your local Du Pont representative can fill you in on availability as well as discuss the possibility of modifying the earlier model with new parts.

Or write for the just-printed Additives Handling Bulletin No. 5.

SALES OFFICES

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Cleveland 15—101 Prospect Ave. ..... MAin 1-3422
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Los Angeles 17—612 So. Flower St. ..... MAdison 4-1354
New York 20—45 Rockefeller Plaza ..... COlumbus 5-2342
Philadelphia 2—3 Penn Center Plaza ..... LOcust 8-3531
Pittsburgh 22—1 Gateway Center ..... ATlantic 1-2933
San Francisco 4—111 Sutter St. ..... EXbrook 2-1934
Seattle 3—4003 Aurora Ave. ..... MElrose 2-6977
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In Canada—Du Pont of Canada Limited, Petroleum Chemicals, 85 Eglinton Ave. East,
Toronto 12—Ontario ..... HUdson 1-6461
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Better Things for Better Living
... through Chemistry

Du Pont Tetraethyl Lead and other Petroleum Additives

OVER

ADVERTISEMENT—Prepared for the Petroleum Chemicals Division of E. I. du Pont de Nemours & Company (Inc.)

A-12705

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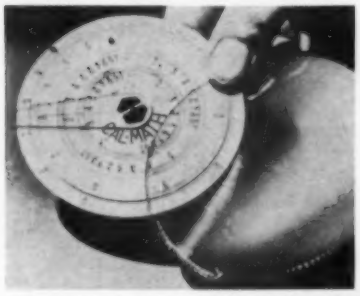
New Equipment

Circular Slide-Rule

Pocket-size circular slide-rule is constructed of two durable aluminum discs and clear plastic hairline indicator. Calculations are performed automatically by



turning discs and indicator. Glare-free green and gold surface prevents light reflection. Large numbers and graduations, and increased spacing between scales make it easy to learn to use. Only 3½ in. in diam it fits easily into shirt pocket. Resistance to corrosion, perspiration and abrasion make it practically indestructible in normal use. *Edmund Scientific Company.*

Circle number (48) on reply card.

Compiler and Translator

Act I, new compiling routine and translator for the Royal Precision LGP-30 electronic computer has been announced. Programming with new compiler can be learned in one day. With its aid any problem can be submitted to computer in simple algebraic form. Compiler is fed into the LGP-30's 4096-word internal memory on punched tape, and translated problems to machine language automatically. It need not remain in machine at compute time, thus preserving entire memory for useful calculation. Act I is capable of compiling fixed or floating point programs. Programming time is greatly reduced, thus allowing faster computer solutions to engineering and management control problems. *Royal McBee Corporation, Data Processing Division.*

Circle number (49) on reply card.

Identification Clamps

All-stainless steel, corrosion resistant Flagmaster clamps attached to stainless steel straps can be quickly and firmly fastened to pipes, light stands, poles or machinery for fast identification purposes. Costly mistakes and delays are eliminated. They are reusable and fully adjustable

within the diameter range ordered. Only four band lengths are required to fit all diameters from 2⅝-16 in. *Aeroquip Corporation, Marman Division.*

Circle number (50) on reply card.

"The Bendix G-15 computer helps plan operations for our ultra-modern refinery."

says JOHN W. RUSSELL,
Process Engineering Analyst,
OHIO OIL COMPANY,
Robinson, Illinois Refinery

"In the highly competitive oil industry, efficiently planned refinery operation is a must. To handle the complex mathematics involved in this planning, we needed the speed of electronic computing. After careful study, we have installed a Bendix G-15 and although it is one of the lowest priced machines, we are using it very successfully on large scale problems. We like the compact size and have found reliability to be exceptional. G-15 users share valuable programs through their own organization, too, and this adds materially to the computer's value."

THE G-15 PROVIDES – Low-cost versatility for thousands of office and laboratory applications – Simplified operating methods – Memory and speed of computers costing four times as much – Typewriter input-output, paper tape output and 250 char/sec paper tape input at no added cost – Expandability through accessories for 1,200,000 words of magnetic tape storage and punched card input-output – Extensive program library – Users share programs – Proven reliability – Nationwide service – Lease or purchase.

Bendix Computer

DIVISION OF BENDIX AVIATION CORPORATION

Built and backed by Bendix, the G-15 is serving scores of progressive businesses large and small throughout the world. For details, write to Bendix Computer, Department L-7, Los Angeles 45, California.

for **leakproof, pressure-tight connections**

use **TiteSeal**®

SEALING COMPOUNDS

Heat and vibration-proof, non-solvent, will not shrink, crack or crumble. Makes all assemblies leak-proof and pressure-tight. Prevents rust, corrosion, joint seizure.

7 BASIC BLENDS

LIQUID WRENCH®

The super-penetrating rust solvent

LOOSENS

rusted bolts, nuts, screws, 'frozen' parts

Liquid Wrench works *fast*...yet is absolutely safe for all metals and alloys.

2171

At Industrial, Automotive, Hardware, Plumbing Jobbers

SOLDER SEAL

RADIATOR SPECIALTY CO.
Charlotte, North Carolina

New Literature

Computer Control Brochure

Complete details on Hagan PowrMag solid state analog computer control systems are presented in a bulletin just issued. Diagrams are presented to show interchangeable circuits possible for various control functions. Numerous applications for PowrMag to industrial process control are suggested, with emphasis on centralized plant or multi-plant control, the expansion of existing control facilities, systems requiring direct tie-in with data processing or digital computer equipment, and other process control functions. *Controls Division, Hagan Chemicals & Controls, Inc.*

Circle number (51) on reply card.

Butterfly Valve Bulletin

New catalog which illustrates and describes new Monoflange Mark II Rubber Seat Butterfly Valve, has been designed to be the ideal working tool for engineers and users of this type of equipment. *Henry Pratt Company.*

Circle number (52) on reply card.

Data Processing Booklet

New 48-page publication describes Leeds & Northrup's data processing equipment in use, including digital data processing and analog and digital computing systems. Heavily illustrated free booklet explains types of inputs, input switching, output devices and modes of operation for applications in electric power, petrochemical, aeronautics, agriculture and other fields. *Leeds & Northrup Company.*

Circle number (53) on reply card.

Ultrasonic Cleaning Bulletin

Alkaline and acidic detergents are frequently better for ultrasonic cleaning than the more viscous solvents. This is one of 6 practical tips given in new Service Bulletin. Based on extensive field work with this cleaning method, bulletin describes process by which high frequency sound waves impart intense scrubbing action to solutions to speed precision cleaning. Method's success, however, depends largely on cleaning solution. *Oakite Gas Atmospheres, Inc.*

Circle number (54) on reply card.

Corrosion Inhibitors

Brochure on KONTOL Corrosion Inhibitors is supplemented with schematic diagrams, detailed engineering drawings and photographs. Application of inhibitors to various refinery systems is explained and evaluated. Eight-page booklet describes how and why KONTOL is effective in correcting such problems as hydrogen blistering, and in supplementing pH control. *Tretolite Company division of Petrolite Corporation.*

Circle number (55) on reply card.

Drying Equipment

Drying equipment available for removal of moisture from low pressure gas or air streams is described in bulletin which features fully automatic refrigeration and solid adsorbent dryers that can be used independently or in combination. *Gas Atmospheres, Inc.*

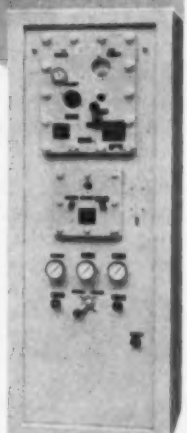
Circle number (56) on reply card.

DETERMINE Moisture CONTENT

of **JET FUELS**
OILS
GASES

with the

MODEL W ELECTROLYTIC MOISTURE ANALYZER



Full scale on most sensitive range,

to one milligram of water per liter of liquid. To 10 p.p.m. of moisture by volume in gases.

Direct reading scales—no computation necessary.

Includes novel self checking features.

Explosionproof Universal Model W. (Other models including portable models for moisture in gas are available.)

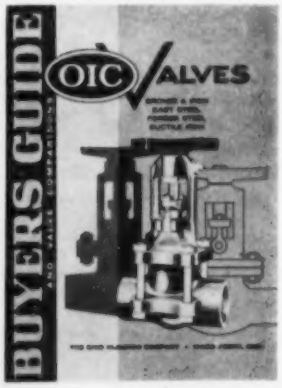
Write for complete information.

MANUFACTURERS ENGINEERING & EQUIPMENT CORP.
Sunset Lane & York Rd. · Hatboro, Pa.

MECCO Instruments

Valve Buyers Guide

In the interest of producing an all-inclusive information piece for valve specifiers, users, and purchasers, OIC has designed a new "Buyers Guide" with valve comparisons. In addition to cross indexing the complete OIC line with the valves of 16 major manufacturers, the guide contains list of frequently used abbreviations, valve trim chart, list of valves conforming to Federal specifications, and complete figure number descriptions. A breakdown of the OIC product line by valve material and pressure class, and classification by type, disc design, seating arrangement, stem operation, bonnet, and end connection serves as an additional guide to proper valve selection. Availability of all this information under one cover provides convenient reference material for purchasing agents, engineers, operating and maintenance personnel, as well as management people who require valve specifications in condensed form. *The Ohio Injector Company.*



Circle number (57) on reply card.

Data System Brochure

Complete description of Kybernetes Series 2000 Data System is provided in 12-page brochure just released. Illustrated brochure outlines construction and operation of basic modular chassis in the Series 2000, including plug-in housings and pinboard arrangement for function programming. Technical data is provided on all functions of the equipment, including inputs, d-c amplification, analog-to-digital conversion, linearization, programming, integration, computer control, and many others. Specifications are also presented for all components and functions of the system, together with a typical system block diagram. *Control Division, Hagan Chemicals & Controls, Inc.*

Circle number (58) on reply card.

Choosing an Antioxidant?

DALPAC® 4 SAVES YOU MORE

Refinery customers have found that, in comparison with other inhibitors, Dalpac 4 (Hercules 2,6-di-tert-butyl-p-cresol) saves up to three dollars on every thousand barrels of gasoline produced. Dalpac 4 inhibits gum formation, stabilizes gasoline color, and helps maintain engine cleanliness. Refiners have also found it to be excellent in turbine and transformer oils where it prevents deterioration, and does not affect electrical properties.

For additional information write:

Oxychemicals Division
Naval Stores Department
HERCULES POWDER COMPANY
900 Market Street
Wilmington 99, Delaware

N-59-58

Refining Personals

Emil Pfister, veteran of the refining industry, recently joined Universal Oil Products Company as consultant. He began his career in petroleum refining in 1920 at the Royal Dutch Shell laboratories in Amsterdam. Since 1929 he served as manager of the Royal Dutch Shell group of refineries in various parts of the world. Following the war, until his recent retirement, he was with Asiatic Petroleum Corporation, New York, in charge of all technological matters connected with the refining and petrochemical industries.

Emil Pfister

W. M. V. Ash

W. M. V. Ash, president of Shell Oil Company of Canada, Ltd., has been appointed vice chairman of HRH The Duke of Edinburgh's Second Commonwealth Study Conference to be held in Montreal, Canada, in 1962. The Conference will be attended by Industrialists and trade unionists from the Commonwealth and the Empire.

Dr. Arthur J. Freedman, formerly in the engineering research department at Standard Oil of Indiana, has been named research project leader at Nalco Chemical Company. He has done extensive research on refinery process corrosion, inhibitor development, and electrical resistance methods for monitoring corrosion rates.

J. A. Dinwiddie

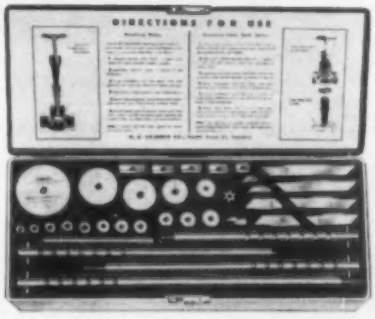
W. C. Jones

R. V. Comeaux

Dr. J. A. Dinwiddie has been promoted to section head and **W. C. Jones** and **R. V. Comeaux** to research specialists in Humble Oil & Refining Company's research and development division at Baytown, Texas.

Dr. Dinwiddie heads a section that is engaged in analytical research and organic analysis; Jones specializes in development and application of various separation techniques to quantitative analysis and Comeaux does research on corrosion problems.

RESEATS VALVES and BIBBS QUICKLY ECONOMICALLY



Easily pays for itself on the first two jobs!

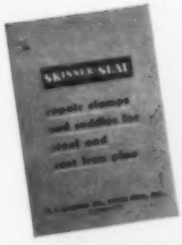
Reseats flat and tapered-seat globe or angle valves—all bibbs and faucets—in place, quickly and accurately. The saving, over tearing out and renewing leaky valves and fixtures, is tremendous.

Cutters operating under screw feed, leave worn, scored seats glass-smooth, level, absolutely accurate and tight.

A guide pilot centers each cutter; a tapered cone centers each spindle. Perfect alignment is inevitable. Cutters guaranteed. Write for literature!

2" for ¼" to 2" valves and ¼" to ¾" bibbs
List price $59.85

3" for ¼" to 3" valves and ¼" to ¾" bibbs
List price $79.50



FREE **catalog showing our pipe repair clamps, saddles, and reseating tools**

M. B. SKINNER CO.
SOUTH BEND 21, INDIANA

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

DE LAVAL

CENTRIFUGAL COMPRESSORS

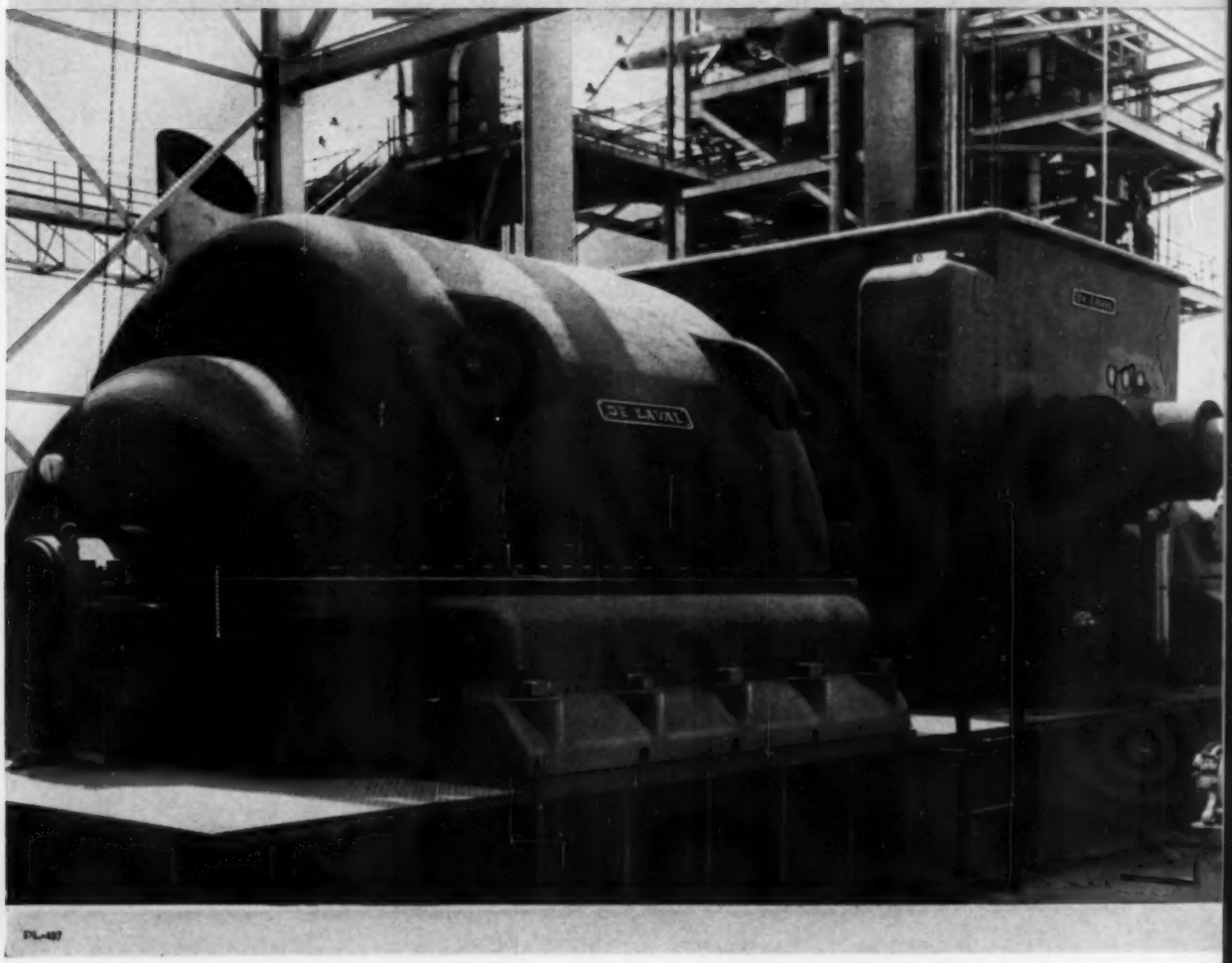
11,300

Driven by automatic extraction steam turbine

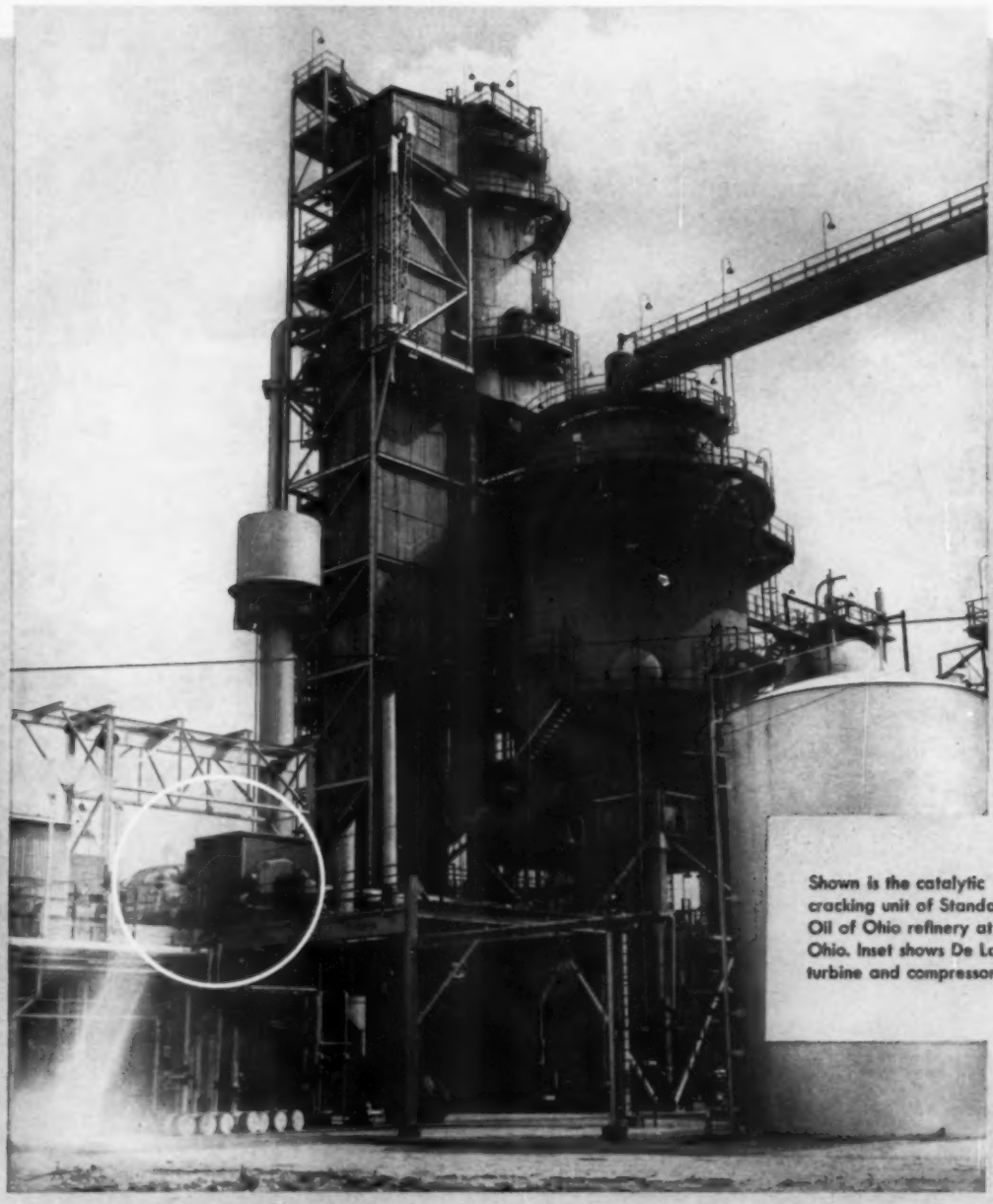
Shown, below is the large 11,300 horsepower centrifugal blower which compresses air for the main blower service in catalyst regeneration at Standard Oil of Ohio's new refinery at Toledo, Ohio.

Driven by a De Laval single automatic extraction steam turbine, it compresses 110,300 cfm in four stages at 2800 rpm. Inlet pressure is 14.7 psia and discharge pressure is 40.7 psia. The turbine is designed for 600 psig ISP, 740F extracting at 55 psig, and exhausting to 28" Hg.

This is another example of De Laval proved performance.



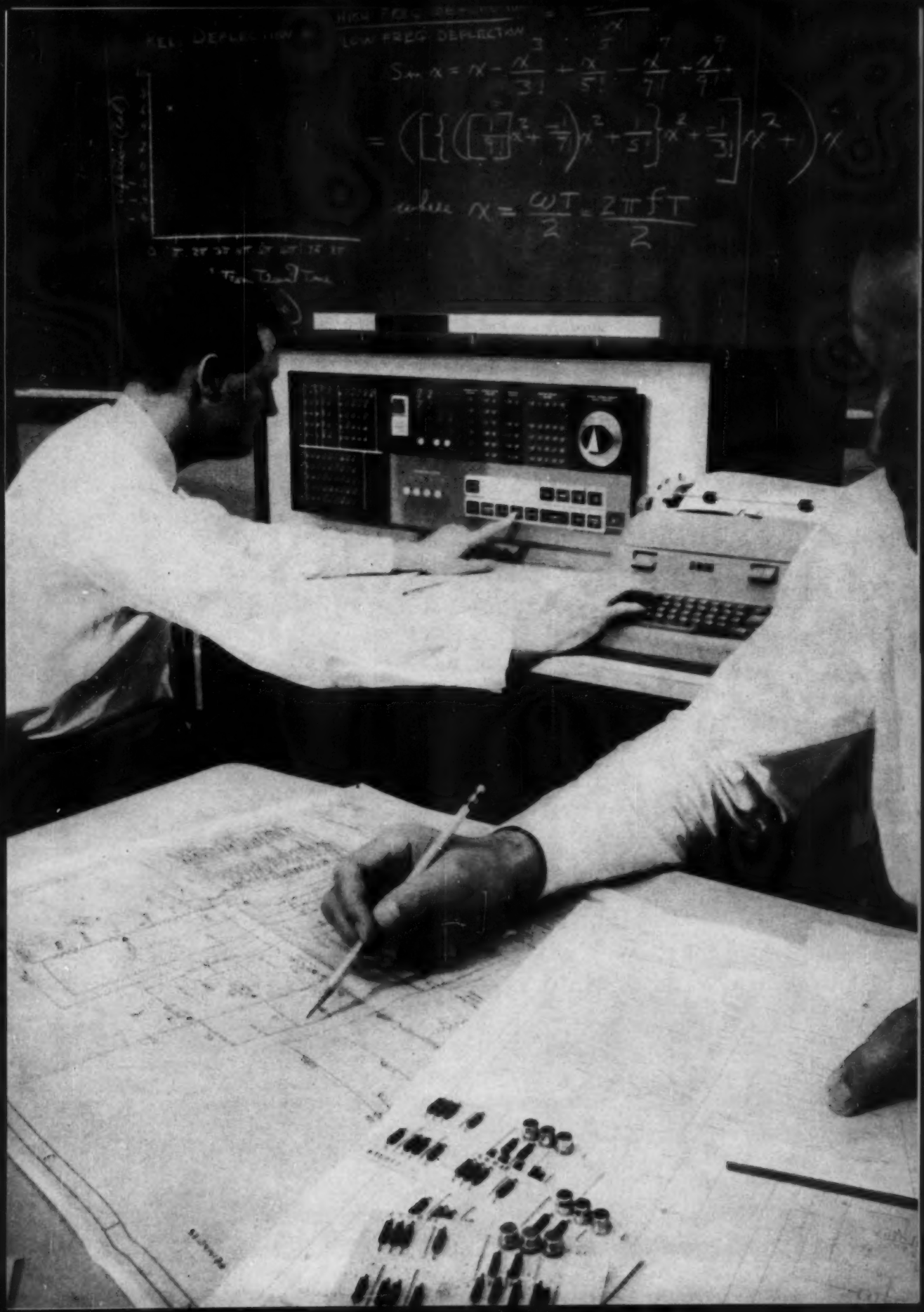
horsepower DE LAVAL compressor for "cat cracker" at SOHIO refinery



Shown is the catalytic cracking unit of Standard Oil of Ohio refinery at Toledo, Ohio. Inset shows De Laval turbine and compressor unit.

DE LAVAL *Steam Turbine Company*

NOTTINGHAM WAY, TRENTON 2, N. J.


HIGH FREQ. DEFLECTION
LOW FREQ. DEFLECTION
$\sin x = x - \frac{x^3}{3!} + \frac{x^5}{5!} - \frac{x^7}{7!} + \frac{x^9}{9!}$
where $x = \frac{\omega T}{2} = \frac{2\pi f T}{2}$

announcing the new

IBM 1620

first solid state engineering computer in the low-price field

Here is a new and powerful stored program, desk-size computer designed to bring more computing ability to engineering problems at low cost.

Transistorized throughout, the IBM 1620 is the only solid state, core-storage computer in its price class.

Easy to learn—easy to operate—easy to communicate with—this powerful computer relieves engineers from routine calculations—frees them for creative tasks.

Data is fed into the 20,000-digit magnetic core memory of the 1620 via punched paper tape. Alpha-numeric output is printed at the console typewriter in desired format, under stored program control.

This new computer with its two-address instruction format and variable field length, gives you up to 50% more storage capacity than a fixed word-length system.

All notations of input and output are in the decimal system. An unlimited decimal field and internal self-checking assure accuracy. A powerful two-address instruction format adds to the 1620's timesaving capabilities.

Programming is simplified through the use of IBM Fortran—a mathematical programming system which compiles machine instructions from algebraic and English language notation. A library of programs for standard engineering computations will also be part of the 1620 package.

Call your IBM representative—ask him to show you all the unique features of the IBM 1620. Like all IBM data processing equipment, this system may be purchased or leased.

BALANCED DATA PROCESSING

IBM

Balanced Data Processing combines systems and services inseparably to produce performance in the best tradition of more than 45 years of IBM experience. It means more production per data processing dollar for you.

B&W LECTROSONIC

A New Name for Carbon Steel Heat Exchanger Tubing

Dependability Proved by Five Years' Extensive Field Service

You get substantial savings with this sounder, more uniform tubing

B&W LECTROSONIC—a new name for heat exchanger tubing—is manufactured under the most exacting methods of quality control in the industry, to give you new standards of dimensional exactness and uniformity, ease of installation, and dependability—plus dollar-saving economy!

You can save on installation time. Every tube fits right and rolls in easily because it's uniform in size and tolerances. It bends easily *with the weld in any position.*

The weld is checked five ways—including 100% ultrasonic inspection—to give assurance of dependability.

This superior quality tubing was developed to meet the needs of the petrochemical industry for a dependable electric resistance welded carbon steel tube that is easily workable, strong, and less costly than seamless tubing formerly required.

B&W LECTROSONIC Tubing is available now either direct or through distributors.

Write today for B&W Bulletin TB-431 for full information—or call your nearest B&W District Sales Office. The Babcock & Wilcox Company, Tubular Products Division, Beaver Falls, Pennsylvania.

B&W

THE BABCOCK & WILCOX COMPANY

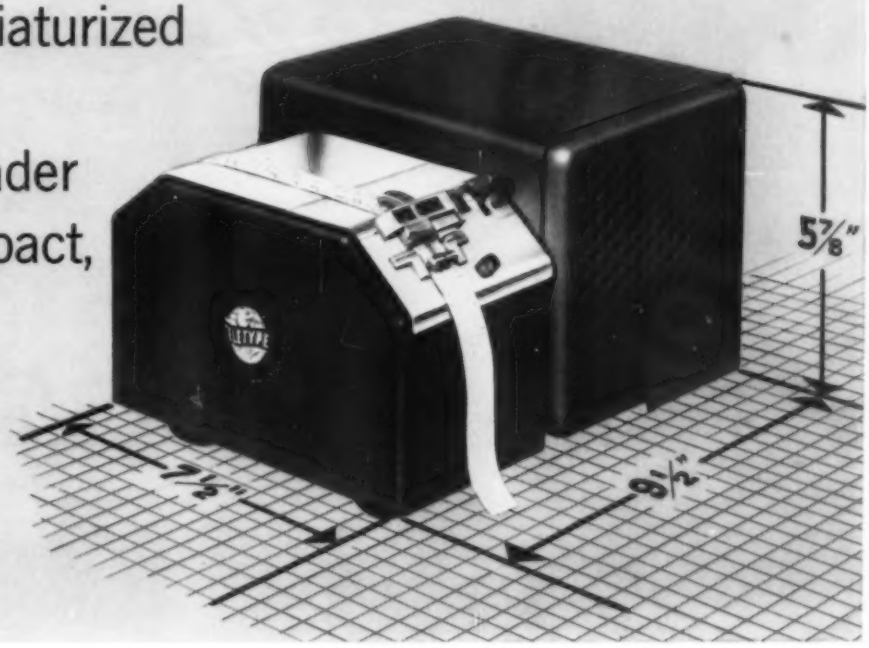
TA-9033-WP4

TUBULAR PRODUCTS DIVISION

Seamless and welded tubular products, solid extrusions, seamless welding fittings and forged steel flanges—in carbon, alloy and stainless steels and special metals

40% reduction in size and weight...

New miniaturized Teletype Tape Reader has compact, space-saving design



Here is a new tape reader set from Teletype Corporation—the Model 28 miniaturized LXD. It features a 40% reduction in size and weight. This new space-saver set is completely compatible with other Teletype communications equipment. It features facilities for sequential (serial) transmission, with optional contacts available for multi-wire output, and it is designed to read either chadless or fully perforated tape.

The Model 28 miniaturized LXD tape reader is made, as is all Teletype equipment, for round-the-clock, day-in, day-out service with minimum maintenance. The unit is equipped with an all-metal clutch that requires lubrication only once or twice a year, and operates with precision accuracy for continuous or intermittent transmission.

New Brochure A 4-page brochure on the new Teletype miniaturized LXD tape reader is available upon request. Write to Teletype Corporation, Dept. 92A, 4100 Fullerton Ave., Chicago 39, Ill.

Specifications

Speed: . . 100 WPM (gears available for slower speeds)
Tape levels: . . . . . 5 or 6
Dimensions: . . . . . 5⅞" H, 7½" W, 9½" D.
Weight: . . . . . Approx. 15 lbs. net
Motor: . . . . . Synchronous, 115 V., 60 Cy.
Finishes: . . . . . Gray-green or custom

TELETYPE®
CORPORATION
SUBSIDIARY OF *Western Electric Company* INC.

How to make tracks at pig-running time!

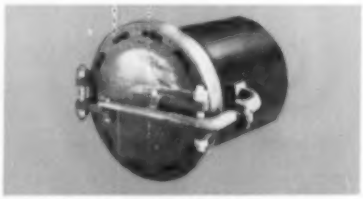
Unibolt hinged scraper traps are the answer

But not even a Unibolt Scraper Trap . . . with its easy-opening two-bolt coupling, its free-swinging hinged closure, its tight-sealing, long-lasting resilient gasket . . . can take all the work out of catching a pig. It comes mighty close, though, to making the job of starting and catching scrapers a trouble-free operation.

Unibolt originated the hinged closure to eliminate the troublesome, time-consuming multi-bolt blind flange. And the Unibolt self-sealing resilient gasket that remains in place when the closure is opened seldom, if ever, needs replacing. This saves you money as well as time. And a Unibolt Scraper Trap installed on an oversize barrel, the i.d. of which is slightly larger than the o.d. of the line, eliminates "fighting" the pig in and out of the trap. Line pressure does the heavy work.

The Unibolt Hinged Blowdown, or blowoff head, is an ideal companion to the Unibolt Scraper Trap on gas line service.

Complete details are carried in Bulletin PL-590, copies of which will gladly be sent on request.



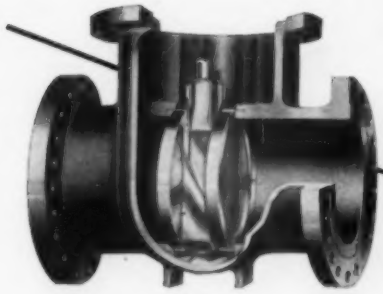
A hinged type Unibolt Scraper Trap in closed position.

UNIBOLT

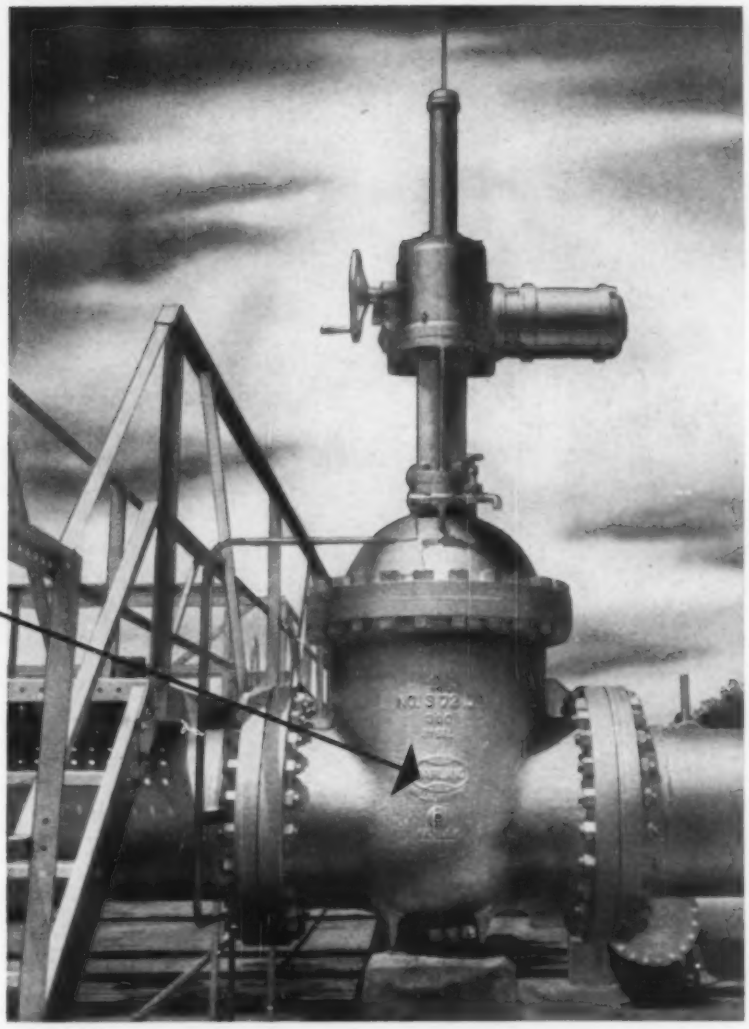
THORNHILL CRAVER CO.

P. O. Box 1184, Houston, Texas

LOOK INSIDE



for dollars to be saved!

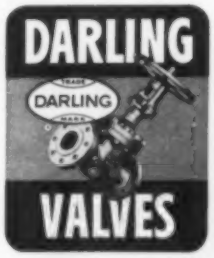


Darling 24", Series 300, motor-operated gate valve, with fully revolving double disc feature, at pipe line terminal of oil pumping station.

SURE! Other things being equal, it's definitely the inside of a gate valve that really tells the story. That's why we show and stress the importance to you of Darling's *fully revolving double disc, parallel seat principle!*

Simple construction, interchangeable no-pocket discs . . . yes . . . but that's only the start. This principle assures uniform distribution of disc-and-seat wear . . . coupled with Darling's unique wedging feature it once and for all licks the problem of faulty closure due to valve body distortion . . . and greatly eases operation even under the most adverse conditions.

That's why oil and gas men everywhere have come to count on Darling gate valves for surer performance, longer life and less down time. It pays. We'll gladly give you *all* the facts on Darling valves for your particular operations. Just ask.



DARLING VALVE & MANUFACTURING CO.

Williamsport 2, Pa.

Manufactured in Canada by Sandilands Valve Manufacturing Co., Ltd., Galt 19, Ont.

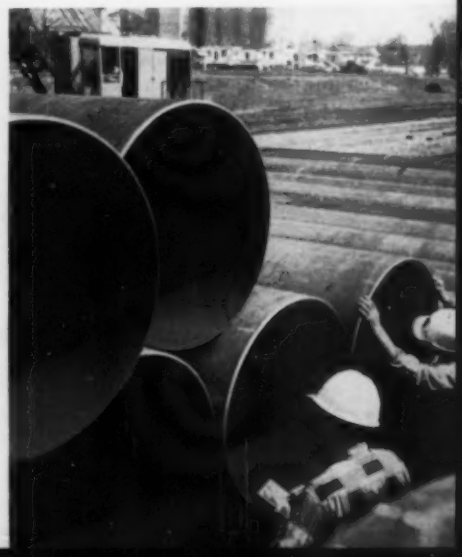
Steel pipe crosses the

Into the Bush Country sixty miles northwest of Corpus Christi, Houston Pipe Line Company trucked ton after ton of Bethlehem Steel line pipe. The pipe was true to round and bevel, so there were no delays as it was welded into a continuous length and buried in the sun-baked Texas soil. Only a few days were required to build the gas-tight pipeline now stretching from the town of George West to a tie-in line 25 miles west of Beeville.

Sheppard Geiger Construction Company, Corpus Christi, tested out the line at 1,050 psi on the first try, and Houston Pipe Line Company approved it for service, reinforcing major gas supplies for Houston Natural Gas System.

BETHLEHEM BUTTWELD LINE PIPE is also popular in the wide open Southwest. Here, Highlonesome Pipeline Company, Abil...e, Texas, installs 3-in. Beth-Co-Weld plain end pipe 25 miles Northeast of Artesia, N. M. Engineered and designed by the Supply Division of Bethlehem Steel Company, the surface line will be a gathering system for Utex Exploration Company and Charles A. Steen of Moab, Utah.

Bethlehem continuous buttweld line pipe, manufactured in sizes from ½ in. to 4 in. (nom.) and in various lengths, can be counted on to meet required specifications.



BIG—BUT NOT THE BIGGEST. This is 36-in. OD electric fusion-weld line pipe, made for a number of Texas-based pipeline companies at our Steelton, Pa., pipe shop. Bethlehem supplies line pipe up to 42-in. OD with walls to ¾ in.

land of sage and sunshine

Bethlehem electric resistance-weld line pipe is a favorite down Texas way. We produce it to required specifications in sizes from 5-in. (nom.) to 16-in. OD, and in lengths to 60 ft. The steel pipe we furnished for this line was 12¾-in. OD x .250-in. wall, API 5L, Grade X-42.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

Export Distributor: Bethlehem Steel Export Corporation

BETHLEHEM STEEL

BETHLEHEM STEEL

You're Money Ahead to

MEASURE PIPE PROTECTION WITH A CALENDAR

How should pipe protection be measured? By first cost? By ease of application? By appearance?

With all the claims made for protective tapes, too often the most important consideration is overlooked—the simple point of how long and how well it will protect the pipe.

Since 1941, when TAPECOAT originated coal tar coating in tape form, this protection has proved to be the best that money can buy for combatting corrosion underground or under water. Lines in service, TAPECOATED as far back as 17 years ago, show no signs of deterioration —a record of uninterrupted performance *no other type of tape can match*. Think what this means in terms of preventive maintenance and elimination of replacement costs!

After all, hot-applied coal tar has proven over the years to be the most dependable and enduring protection. And because TAPECOAT is a hot-applied coal tar coating in tape form, it offers the same lasting protection.

A TAPECOAT sales and service engineer is available at all times to assist you on any corrosion problem and on the various applications of TAPECOAT.

Write for complete details today.

PROVED IN SERVICE

...Underground or Under Water on

Pipe	**Tanks**
Pipe Joints	**Tie Rods**
Service Connections	**Conduit**
Mechanical Couplings	**Cables**
Fittings	**Splices**
Insulated Lines	**Bridge Crossings**

TAPECOAT comes in rolls of 2", 3", 4", 6", 18" and 24" widths—sized to the job. Available also in asphalt. Where primer is desired, specify TC Primecoat, the compatible coal tar primer.

TAPECOAT®

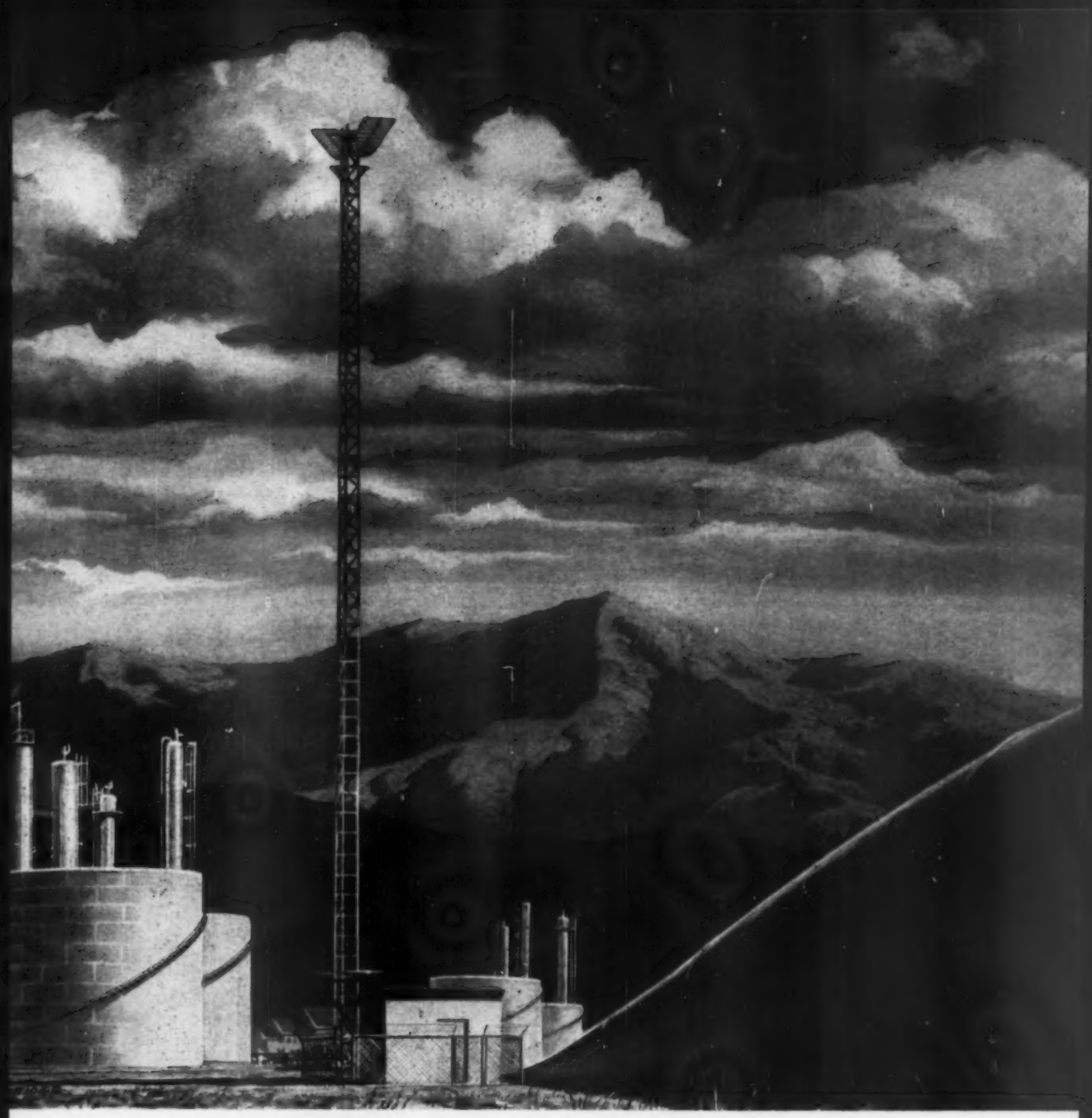
A PROTECTIVE COATING

The **TAPECOAT** *Company*

1567 Lyons Street, Evanston, Illinois

Representatives in Principal Cities

Manufactured and Distributed in Canada by The Tapecoat Company of Canada, Ltd., 25 Haas Road, Rexdale, Ontario.



COLLINS MICROWAVE AND CARRIER

Reliable communication for forward-thinking pipeliners

Collins leadership in the field of communication makes the organization uniquely qualified to supply your complete "turn-key" microwave system — consultant service, planning, siting, equipment design and manufacture, installation, training and field service. Take advantage of this worldwide experience in providing the finest communication service. Consult Collins for your private system, tailored to your individual requirements. Your microwave system will be reliable, flexible and readily adaptable to tomorrow's expansion.

COLLINS

COLLINS RADIO COMPANY • DALLAS, TEXAS • CEDAR RAPIDS, IOWA • BURBANK, CALIFORNIA

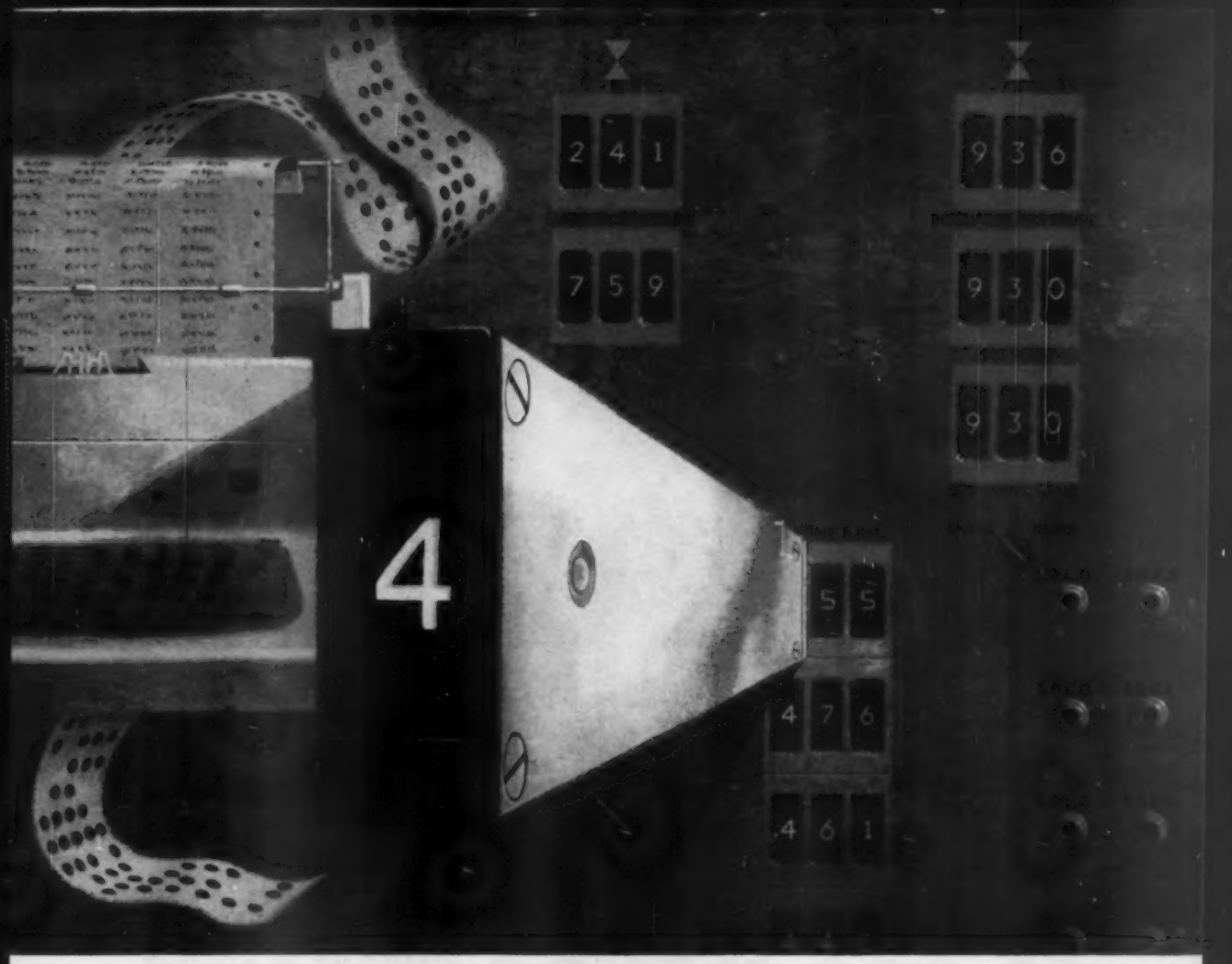
When the trench hits rock bring in the Insley **M's**

When the trench hits rock, hills or swamps, put Insley's proven pipeline performance to work for you. Bring in the Insley M's. The M's modern wide-vision cab houses pipeline features unmatched by any other machine on the market. Take advantage of the "pipeline experience" that's designed into every Insley. Get all the facts today. Ask your Insley dealer for catalog 300-3 or write Insley direct. Or better still, see an Insley M in action. We'll make the arrangements at no obligation to you.

This 22 miles of trenching for 30-inch line runs between Ottawa and Welda, Kansas. The contractor, Vaughn & Taylor, Odessa, Texas, is using three ¾ cu. yd. Insley M's.

THERE'S AN **INSLEY** WORKING NEAR YOU

INSLEY MANUFACTURING CORPORATION • GENERAL OFFICES • INDIANAPOLIS 6, INDIANA



NEW CONTROL CONCEPT
can cut your pipeline costs

Did you ever try to solve a jigsaw puzzle without first looking at the total picture the puzzle makes? Pretty difficult—maybe even impossible. Best way, easiest way is to look at the big picture first, then see where the individual pieces fit.

It's the same with pipeline control.

First, look at your total system problem. Then, determine what sort of control system is required to safely, reliably and economically meet tomorrow's need as well as today's. That is Union Switch & Signal's approach to pipeline control.

Any part of a pipeline system. Union Switch & Signal can incorporate in a centralized control system any or all of the following functions: supervisory or remote control of satellite stations . . . telemetering of flow data from field back to your central dispatching office . . . automatic sequencing or control of equipment in the field . . . instrumentation . . . data handling and display . . . computing equipment . . . automatic integration of field data into your accounting operations . . . communications. Union Centralized Transport Control can be adapted to *any* problem from remote control of a single-unit booster station for gas or oil to automatic centralized control of an entire system from wellhead to ultimate consumer.

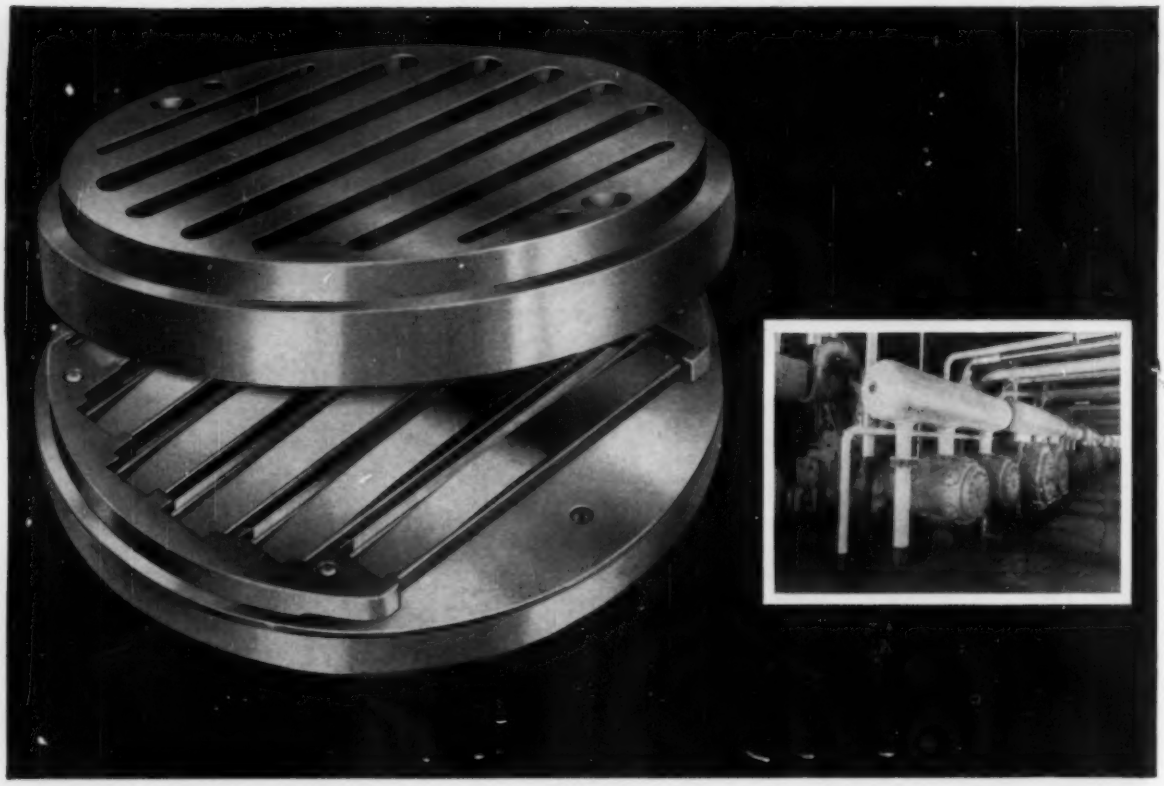
Error-free. Whatever the job assigned to it, Union Centralized Control operates completely free from error because it reduces to coded digital form all information and instructions transmitted to or from your central control office. As a result, you can transmit far more precise data than ever before; you can use the least expensive available communications service; and you never need to worry about lightning, noise or other interference causing a wrong or dangerous operation—this coded system automatically checks itself and responds *only* to correct and logical signals. It helps make your pipeline safer. It provides error-free *security* as well as reliability.

Lower operating cost. Most important, Union Centralized Transport Control cuts your operating costs, cuts the cost of future expansion, sometimes even cuts present installation cost of pumping stations.

Write for Bulletins PD 2006, PD 2007 and 1052

"Pioneers in Push-Button Science"

UNION SWITCH & SIGNAL
DIVISION OF WESTINGHOUSE AIR BRAKE COMPANY
PITTSBURGH 18, PENNSYLVANIA



I-R Channel Valves at El Paso operate

43,000 HOURS *without a single replacement!*

At the Driver Station of El Paso Natural Gas Company, there are ten Ingersoll-Rand 2000-hp KVS gas-engine compressors, each with 56 Channel Valves. These compressors have been operating since New Year's Day of 1954, boosting about 100,000,000 cfd of gas from local tank batteries to El Paso's Midkiff gasoline plant seven miles away. Each KVS has operated more than 43,000 hours, and *not one Channel Valve has been replaced!*

Five valves have been cleaned due to foreign material sticking in them; this constitutes the only valve maintenance for a period of 5½ years, during which *each* of the 560 valves has opened and closed 850,000,000 times!

The secret of performance records like this is the patented I-R Channel Valve design; gas-cushioned action eliminates impact without using heavy parts that kill efficiency or flimsy elements which soon break or wear out. Each Channel Valve is a combination of straight-lifting stainless-steel channels and bowed leaf springs, with trapped-gas spaces which cushion action and prevent impact. The separate stainless-steel seat plate can easily be reversed or replaced for new life, so the valve seat never needs machining.

Performance like this is typical for Ingersoll-Rand equipment. All gas compressors, starting-air compressors, circulating pumps and the auxiliary power unit at the Driver Station are products of Ingersoll-Rand.

Only Ingersoll-Rand compressors have Channel Valves

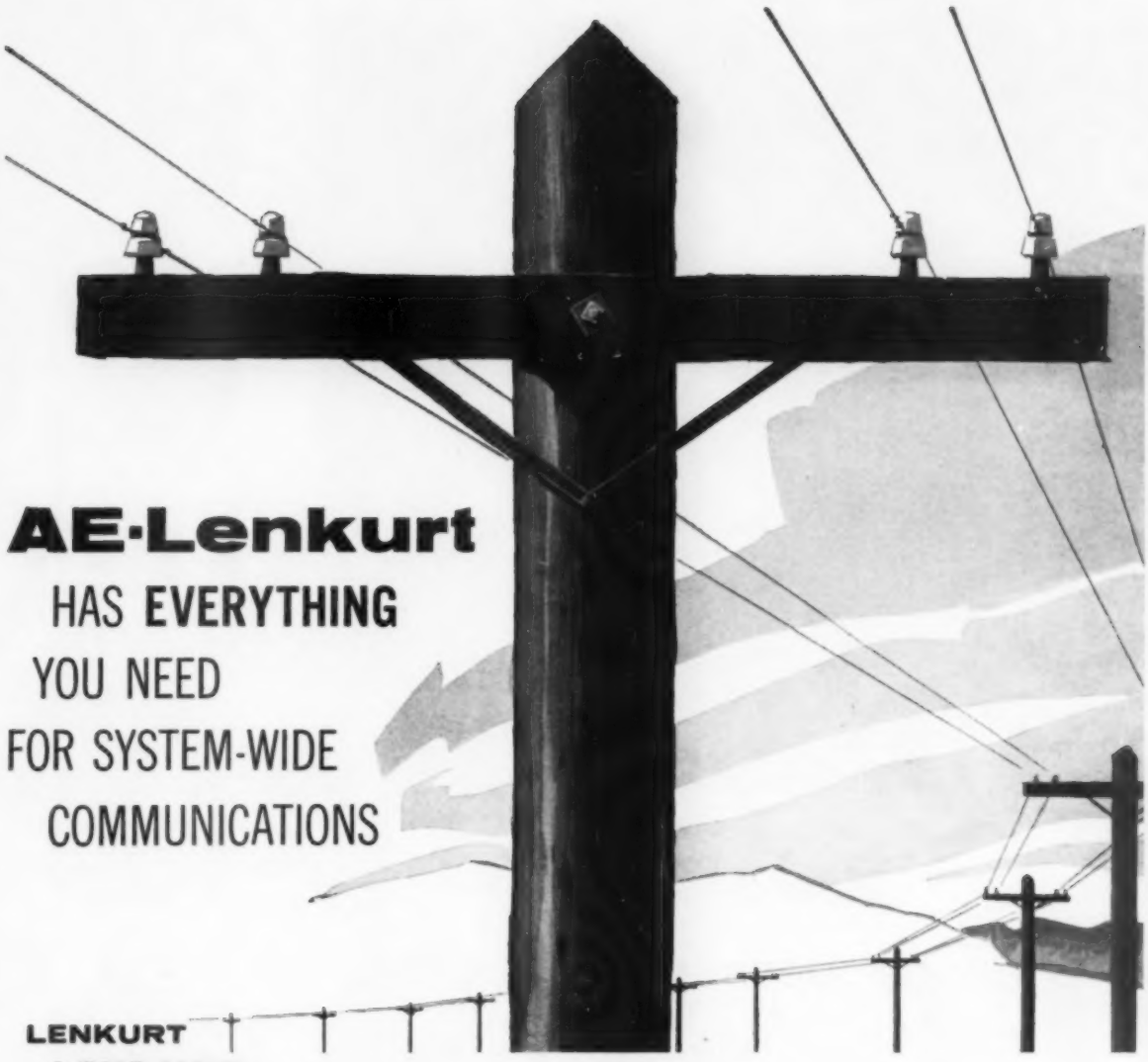
4-CYCLE

Ingersoll-Rand

Ad 6-968

11 Broadway, New York 4, N. Y.

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD



AE-Lenkurt

HAS EVERYTHING YOU NEED FOR SYSTEM-WIDE COMMUNICATIONS

LENKURT LONG-HAUL CARRIER, for instance...

Where distance is a problem, the Type 32E Carrier Telephone System is one of the Lenkurt systems available as a solution. It is an economical and efficient means of adding communication channels to existing wire lines.

Type 32E single sideband suppressed carrier terminals are equipped with either three or four channels in the 3-kc. to 35-kc. range, and can be applied over v-f circuits. With the use of repeaters, these channels can be used for high quality, medium- and long-haul circuits. System levels and frequencies coordinate with those used in Western Electric Type C carrier equipment.

The AE-Lenkurt team of engineers is equipped to handle as little or as much of the planning and installation as you wish. And AE will provide "follow-thru" service *for the life of the equipment.*

For full information on the Lenkurt Type 32E or companion equipment, call your Automatic Electric representative, or write the Director, Petroleum Sales, Automatic Electric Sales Corporation, Northlake, Illinois.

ALL YOUR COMMUNICATIONS NEEDS FROM ONE DEPENDABLE SOURCE

AUTOMATIC ELECTRIC GENERAL SYSTEM

Subsidiary of

GENERAL TELEPHONE & ELECTRONICS

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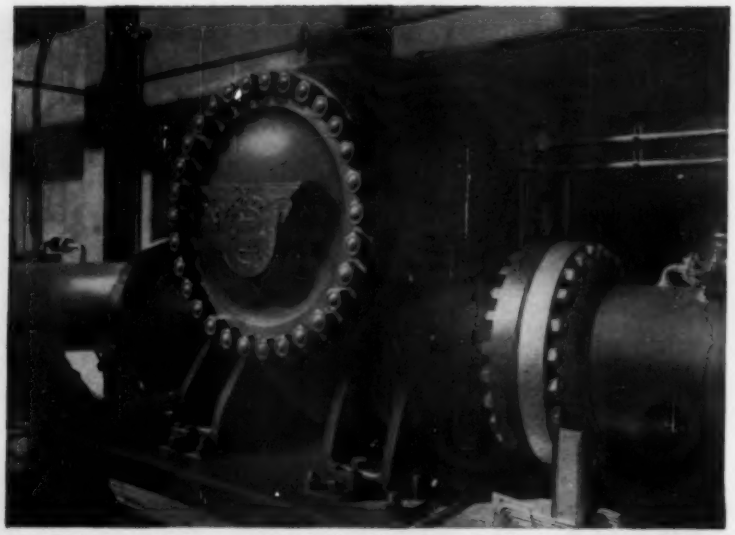


Cooper-Bessemer RFB-24 centrifugals, like this one, powered by Cooper-Bessemer LSV turbocharged gas engines, comprise the world's most efficient pipeline compressor units.

David M. Salls, *Manager, Gas Industry Sales, The Cooper-Bessemer Corporation, explains...*

How 5 Cooper-Bessemer powered, Gulf Interstate engineered stations will give Transwestern peak economy and flexibility

ALL FIVE of the mainline compressor stations of the new Transwestern Pipeline system will be equipped with Cooper-Bessemer engine-driven centrifugal compressors and will be remotely operated. These new automatic, remote-controlled stations will provide unexcelled efficiency and flexibility... a fact proven by the highly successful performance record of this modern equipment in other mainline stations of the same basic design—over 130,000 horsepower to date in mainline service.

The giant Cooper-Bessemer LSV-16 turbocharged gas engines will be of the type shown here. They will drive Cooper-Bessemer RFB-24 centrifugal boosters through speed increasers. Each of the five stations will include two of these high-efficiency compressor units. These units have the highest thermal efficiency obtainable in the gas industry today. The map shows the location of the stations. All units will be automatically controlled from a central point.

We will gladly supply details on this Cooper-

Map shows location of Transwestern's mainline automatic, remote-controlled stations. Background shows type of Cooper-Bessemer LSV-16 turbocharged engines to be used on this new line.

Bessemer equipment, and assist in *your* compressor station plans.

BRANCH OFFICES: Grove City • New York • Washington Gloucester • Pittsburgh • Chicago • Minneapolis • St. Louis • Kansas City • Tulsa • New Orleans • Shreveport • Houston • Greggton Dallas • Odessa • Pampa • Casper • Seattle • San Francisco • Los Angeles

SUBSIDIARIES: Cooper-Bessemer of Canada, Ltd. . . . Edmonton Calgary • Toronto • Halifax

C-B Southern, Inc. . . . Houston

Cooper-Bessemer International Corp. . . . New York • Caracas • Anaco

Cooper-Bessemer, S.A. . . . Chur, Switzerland • The Hague, Netherlands • Mexico City

The Rotor Tool Company . . . Cleveland

Cooper Bessemer

GENERAL OFFICES: MOUNT VERNON, OHIO

ENGINES: GAS - DIESEL - GAS-DIESEL
COMPRESSORS: RECIPROCATING AND CENTRIFUGAL, ENGINE, TURBINE OR MOTOR DRIVEN

Pipe Line Contractors

William Hazlett Upson, author of the famous short stories about Alexander Botts, fabulous salesman for the Earthworm Tractor Company, and J. Howard Marshall, executive vice president of Signal Oil and Gas Company, will be featured speakers at the annual convention of the Pipe Line Contractors Association. Two additional speakers had not been named at the time of going to press.

The contractors meeting this year is being held in Los Angeles, California, at the Ambassador Hotel. Dates are January 31 through February 3. The program follows, with the days on which the speakers will appear to be announced later:

Saturday, January 30

6:00 P. M. President's party — Cocktails — Regency Room
Dinner — Colonial Room

Sunday, January 31

2:00 P. M. Board of Directors' Meeting — Frenchette Room
5:30 P. M. Reception — Big Three Welding Equipment Company, Houston, Texas — Embassy Room
7:00 P. M. Dinner Dance — H & L Tooth Company, Montebello, California — Cocoanut Grove

Monday, February 1

7:30 A. M. Early Birds Breakfast — Insley Manufacturing Corp., Indianapolis, Indiana — Venetian Room
10:00 A. M. General Business Meeting — Venetian Room
12:00 Noon Ladies Luncheon — Allis-Chalmers Manufacturing Corp., Milwaukee, Wisconsin
Men's Luncheon — M. J. Crose Manufacturing Co., Tulsa, Oklahoma — Venetian Room

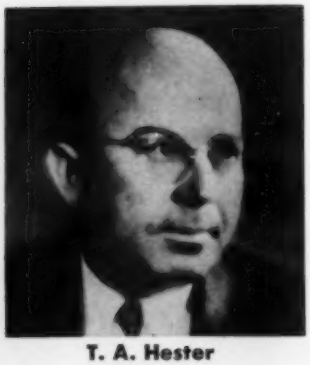
John H. Williams
President

R. D. Sheehan
1st Vice President

M. S. Williams
2nd Vice President

Felix Johnson
Treasurer

R. P. Gregory
Director



T. A. Hester
Director

E. G. Morrison
Director

Schedule Interesting Program

2:00 P. M. Gin Rummy Tournament — Polyken Sales Division The Kendall Company, Chicago, Illinois, — Grove Lounge

6:00 P. M. Cocktails and Dinner — Caterpillar Tractor Co., Peoria, Illinois — Cocoanut Grove

Tuesday, February 2

7:30 A. M. Breakfast — Louisiana Machinery Co., Monroe, Louisiana — Venetian Room

10:00 A. M. General Business Meeting — Venetian Room

11:30 A. M. Election of Officers

12:00 Noon Luncheon and Show — Crutcher-Rolfs-Cummings, Inc., Houston, Texas — Cocoanut Grove

2:00 P. M. Gin Rummy Tournament — Polyken — Grove Lounge

6:00 P. M. Cocktails — International Harvester Co., Melrose Park, Illinois, and Superior Equipment Co., Bucyrus, Ohio — Embassy Room

7:30 P. M. Banquet and Floor Show — Cocoanut Grove

Wednesday, February 3

8:00 A. M. Meeting of New Board of Directors — Frenchette Room

9:30 A. M. Labor Meeting — Colonial Room

12:00 Noon Adjournment

Richard A. Gump
Executive Secretary

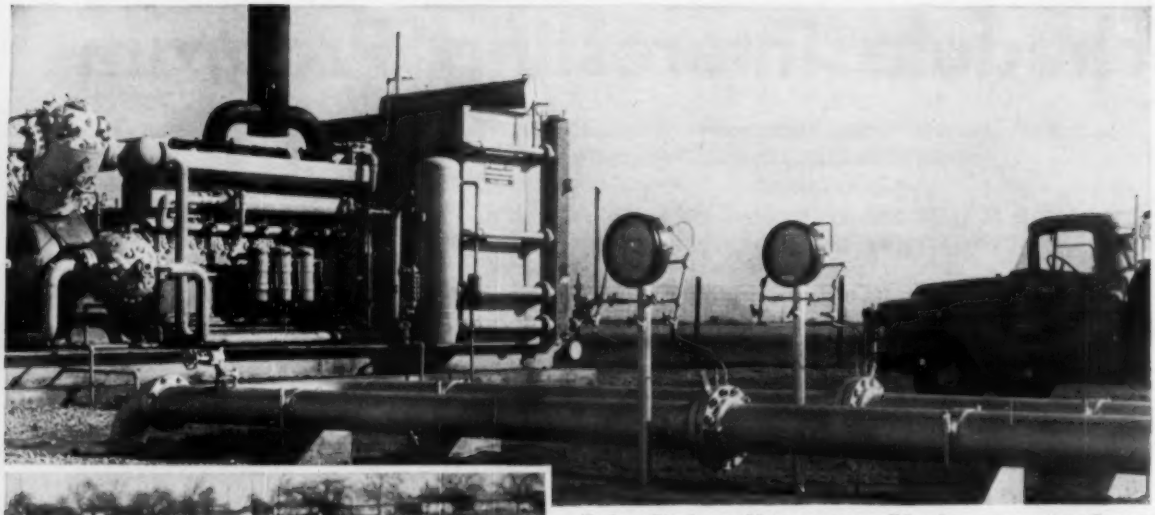
O. R. Burden
Director

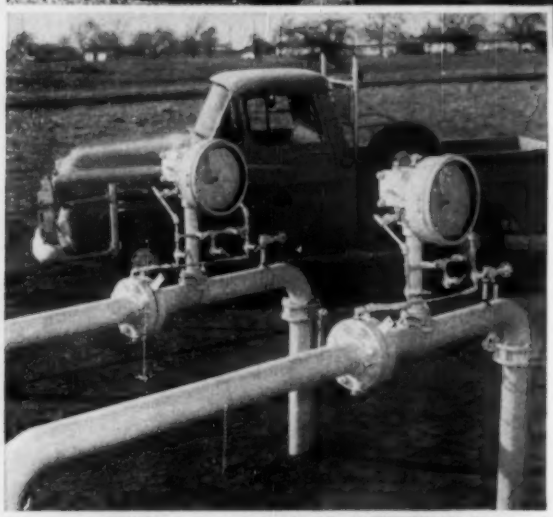
Jack Gray
Director

James P. Neill
Director

H. C. Price
Director

R. B. Somerville
Director





Foxboro Diaphragm Meters on gas well head measurements at Sunray Mid-Continent's Moore, Oklahoma field. Meters return to zero instantly when flow stops — have no ambient temperature effects, even though temperatures have ranged from −9°F to +105°F.

"the only dry meter with the solid pen-power of a mercury meter"

. . . reports H. H. (Pat) Everett
Sunray Mid-Continent Oil Co.

Fastest zero return of any dry meter on intermittent gas flows. That's just one reason why Sunray Mid-Continent Oil Co. finds the Foxboro Type 37 Diaphragm Meter perfect for gas wellhead flow measurements.

Sunray currently has 47 Diaphragm Meters in operation on gas separator and compressor stations in the Oklahoma City district, with 13 more due to be installed shortly.

District Superintendent H. H. (Pat) Everett also reports that his Diaphragm Meters have never needed calibration since they were installed. And they're completely free from zero drift and ambient temperature effects . . . resulting in the highest sustained accuracy of mercury-less gas flow measurement. No wonder Sunray says the Type 37 outperforms all other dry flow meters!

You'll find Foxboro Diaphragm Meters provide highly accurate, dependable records of all gas flow measurements. Get full details from your nearby Foxboro Field Engineer, or write for Bulletin 7-15A. **The Foxboro Company, 381 Norfolk St., Foxboro, Massachusetts.**

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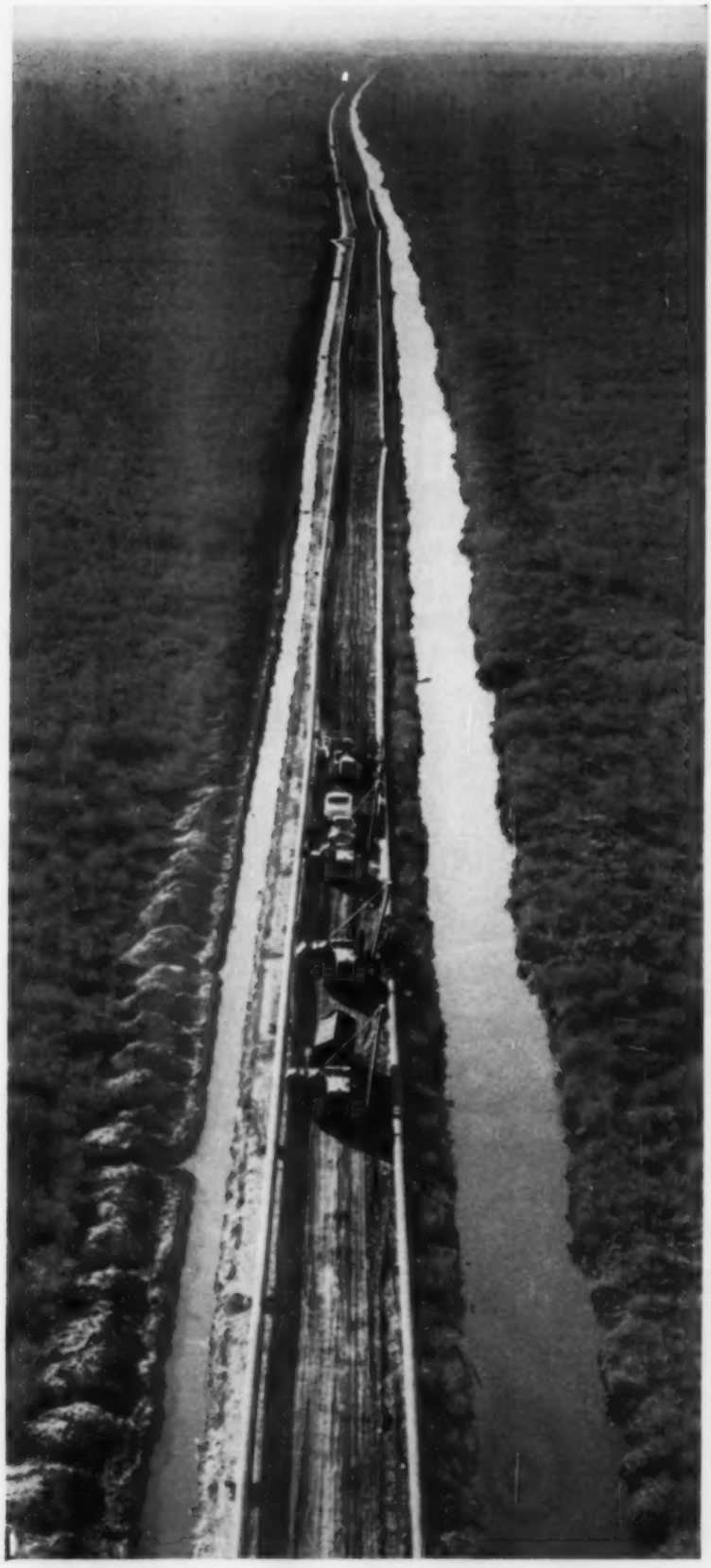

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. . . Wrap this rugged tape around 30 miles of 24-inch gas line in the swamp water and coral rock of southern Florida. Let an Iranian oil company use it on 200 miles of desert oil line. Put it to work for the Phillips Petroleum Co. in Texas and Canada.

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Outlook for 1960

Pipeline Executives Foresee Good Year Ahead

Continued expansion of physical plant, major developments in automation, increased operating efficiency, and possibility of no adverse legislation are among predictions

During 1959 the pipeline industry had several judicial battles decided in its favor, such as the Arapahoe Case and the Consent Decree ruling, and in this respect the outlook at the beginning of the year is brighter than it was a year ago. But, as one executive says, this should not lead to complacency because "the threats against the pipeline industry continue as real and as imminent as ever."

In other respects, too, the industry can look ahead with satisfaction. Apparently there will be no letup in gas pipeline expansion. Products pipeline growth also will be substantial, whereas expansion of crude oil systems will be more gradual. Need for increased throughputs of crude will be taken care of largely by looping and adding pumping horsepower.

Greater operating efficiency to offset higher operating costs will again be the order of the day. Automation looms large and major developments are expected in this area. Furthermore, in addition to technical advancements, increased labor costs could result in certain borderline projects being installed sooner than anticipated.

The consensus of operating company executives reporting to the PIPELINE ENGINEER is for a good year in respect to expansion, technological developments, operating efficiency, and perhaps no adverse legislation. Their comments follow:

California Gas Demand Continues Big

Robert A. Hornby
President
Pacific Lighting Gas Supply Co.

NO DOUBT ANY discussion of continued and continuing growth in southern California may by now have become as tiresome as warmed-over hash, and just about that palatable to those in other parts of the country.

To be sure, southern California does not have a monopoly on expansion. Nevertheless, its growth continues at such high rates as to be astonishing and, at times, disquieting to those who must plan and provide for the essential services to take care of the area's burgeoning population.

Among those so disquieted are, of course, the utilities. The Pacific Lighting system, of which Pacific Lighting Gas Supply Company is a member, (the others are Southern California Gas Company and Southern Counties Gas Company) now provides gas service to more than 2,360,000 meters. Its plant properties stand at $782,000,000, with more than $553,000,000 having accumulated since World War II.

Estimates are that by 1975, the P. L. system must stand prepared to render gas service to 4,500,000 meters, while its plant will have passed the $2,000,000,000-mark.

And the population boom described by these statistics comes in the face of declining California production of natural gas, thus requiring importation of ever greater quantities of out-of-state gas.

To meet the demands of its customers, the Pacific Lighting system now plans two new out-of-state supply projects. One of these, with an initial 300,000,000 cu ft of gas daily from Transwestern Pipeline Company is already under construction. Pacific Lighting Gas Supply Company is now scheduled to take deliveries from Transwestern by the fall of 1960. The Transwestern pipeline system can be expanded to handle 600,000,000 cu ft of gas a day.

Hearings on the Rock Springs project have been completed before the California Public Utilities Commission and a decision is pending. El Paso Natural Gas Company, Colorado Interstate Gas Company, and Pacific Northwest Pipeline Corporation have filed applications with the Federal Power Commission covering their respective out-of-state portions of the project. Hearings are expected to begin within the next 90 days.

Deliveries in the Rock Springs project to PLGS's affiliates, Southern California and Southern Counties Gas companies, now are scheduled to provide an initial volume of 200,000,000 cu ft of gas daily, increasing to 400,000,000 cu ft daily by 1962. The projected pipeline system can be expanded economically to deliver approximately 700,000,000 cu ft a day.

With these two new supply lines in operation, deliveries of out-of-state gas to the integrated Pacific Lighting system will by 1964 gradually build up to 2,000,000,000 cu ft a day. Present contractual deliveries of out-of-state gas are 1,042,000,000 cu ft daily.

Although California gas supplies may no longer loom as important to the Pacific Lighting system as they once were, they nevertheless serve an important function, particularly in providing peaking gas.

To assure continued availability of California gas, Pacific Lighting last year entered into long-term contracts ranging in terms upward to 35 years with producers in the southern half of the state. To date, 92 percent of gas estimated to be purchased in 1960 under the long term agreements is under contract. Preliminary estimates show that gas reserves committed to PLGS under the long term contracts are approximately 4 trillion cu ft.

As to the future: There is little question that Canadian gas will find its way to California markets in substantial quantities. Certificate proceedings presently before the Federal Power Commission for importation of Canadian gas to the U. S. west coast include projected deliveries of 150,000,000 cu ft daily to the southern California market through the Rock Springs project.

Pipeline Outlook

Pipeline Industry Entering New Phase

D. P. Dugan
President
Tuscarora Pipe Line Co.

OFTEN A REMARK is heard that goes something like this: "I suppose that about all the pipelines are now built that we need." Actually, I feel that we are just getting started and about ready to see a new phase in the pipeline industry. We have been, of course, building longer and larger lines for many years but many of them are almost obsolete before they are finished. New developments in materials, methods, equipment, and technological advances have made pipelines one of the most modern methods of transportation in existence today. Many old lines must be rebuilt or replaced with larger sizes and more flexible equipment. We must serve all centers of population and industry with the products they want. The success of the coal pipeline is only one step into diversification. Many more commodities lend themselves to movement by pipeline and the industry will find the methods to move them.

New oil and gas fields are constantly being found in remote places and this takes lines to new refining centers. New refining centers take lines to distribute products. Add to this our rapid growth in population and the redistribution of this population to new centers with new centers of manufacturing and energy requirements and we have a new and constantly changing pattern of distribution that must be served.

I have recently completed a year and a half stay in Europe with NATO. I could see that Europe is just getting awake to the economic advantages and uses of pipelines to serve their large populations and rapidly expanding economy. In the next few years Europe will require thousands of miles of crude and products lines as well as gas lines from North Africa.

With our technological advances in the industry that have resulted in making pipelines more economically competitive with other forms of transportation there is a bright new phase dawning in the pipeline future.

The Second World War served to bring the importance of pipelines to the attention of Americans. Now, not only Americans but all the civilized world is beginning to learn of the advantages. New uses will bring more and more attention to the economic value. Many of our older lines are worn out or obsolete and must be replaced. For these and many other reasons, the pipeline industry should continue to grow for years to come.

Industry Must Keep Its Guard Up

J. L. Burke
President
Service Pipe Line Co.

RESURGENT BUSINESS CONDITIONS and continued technological improvements will almost certainly result in oil pipelines enjoying a share of the nation's anticipated prosperity in 1960. But, while the economic situation appears promising, the political situation will require much attention and affirmative action. The threat of governmental tampering with the structure of the industry will be the greatest concern of oil pipeline management during the year—and the years beyond 1960.

Oil pipelines can point to a number of vindications in the public arena during the past year. Two of these are especially notable: the Supreme Court's favorable decision in the Arapahoe Case; and the inability of the House Antitrust Subcommittee to gain a majority of signatures to its glaringly biased report on pipelines resulting from its investigation of Consent Decree enforcement. In the Arapahoe Case, the vote of the Supreme Court justices was six to one, two of the justices having disqualified. The House Antitrust Subcommittee was comprised of six Democrats and three Republicans. Two of the Democrats would not sign the report and the three minority members severely criticized it as "having no official status."

These accomplishments are the result of affirmative and aggressive action by representatives of the pipeline industry. They show that our arguments are sound and effective. But these successes should not lead to complacency. The threats against the pipeline industry continue as real and as imminent as ever.

Our most effective weapon to combat these threats is a concerted program to inform our employees, public officials, friends, stockholders, and the general public of the true pipeline story. The successes the pipeline industry has gained in these controversies can largely be attributed to someone, a congressman, a committee member, a commission member, a newspaper or magazine editor, gaining understanding. If people—through leaders first and the public generally—can be shown that the transportation arm of the oil industry performs a function that is unparalleled in its economic contribution to the public welfare, most of our battles will be won. All of us in the industry know this, but to convey it to the public against a welter of misleading propaganda is a herculean task. It will require the thoughtful attention of management for a great many years.

No Letup in Gas Pipeline Expansion

Ralph T. McElvenny
President
American Natural Gas Co.

NATURAL GAS PIPELINE companies as a whole have suffered a unique experience in American industry since World War II, in that they have rarely been able to expand fast enough to meet the needs of their markets.

I say "suffered" because its been a difficult period of purchasing new reserves, which producers were reluctant to commit in view of federal regulation, while at the same time trying to keep peace with distributors who always needed additional gas.

Pipelines could hardly commence a new expansion program before they discovered that even their most liberal estimates of demand soon fell short of satisfying market requirements.

I see no immediate end to this situation, despite the fact that every major population center in the nation is now or soon will be served with natural gas.

A look at the record shows gas usage has increased about 250 percent every 10 years and the gas industry predicts that sales will increase by about this percent in the next decade.

There was a time not long ago when even the largest cities felt fortunate if they had natural gas. Now every little hamlet feels it is being discriminated against if it does not have access to this wonderful fuel.

Perhaps American Natural Gas Company and other companies which operate integrated systems consisting of both transmission and distributing companies are more acutely aware of this problem than are the independent

pipelines, since the integrated companies have a direct relationship with the consuming public.

To satisfy the needs of the public, the American Natural system has been in a constant state of expansion. Since the beginning of 1948, in addition to major expansion of distribution facilities, we have built two major transmission systems, Michigan Wisconsin Pipe Line Company and American Louisiana Pipe Line Company, at a cost of over $300,000,000.

This year Michigan Wisconsin is completing a $40,000,000 project to increase its capacity by 80,000,000 cu ft a day from the newly developed Laverne field in northwestern Oklahoma. American Louisiana is spending $6,000,000 on two new compressor stations to deliver an additional 43,000,000 cu ft a day from fields in Louisiana.

By next spring Michigan Wisconsin expects to be laying pipe in Wisconsin and expanding its system in other areas to take 158,000,000 cu ft a day from Midwestern Gas Transmission Company, which recently won Federal Power Commission approval to import Canadian gas at Emerson, Manitoba, from Trans-Canada Pipe Lines Limited.

With the tremendous increase in demand for gas — and particularly the preferred use for house heating — the problem of balancing seasonal fluctuations grows even greater. We accordingly are enlarging underground storage facilities requiring the investment of many more millions of dollars.

Virtually everybody wants gas heat; the population as well as individual usage of energy is increasing at a remarkable rate and industry is finding dozens of new uses for our product every year.

I see a bright future for natural gas pipelines and for the natural gas industry generally, of which the pipelines are a vital segment.

Export Key to Canadian Prosperity

D. M. Morrison
President
Trans Mountain
Oil Pipe Line Co.

PROSPERITY FOR Alberta's oil industry, and especially for Trans Mountain Oil Pipe Line Company, is dependent on the export of petroleum. Since Suez three major factors have exerted an adverse influence on this export business in spite of the helpful presidential proclamation exempting Canadian oil moving overland from import quotas. These are:

World surplus of oil
Low tanker rates
Premium Canadian dollar

The first two seem likely to continue for some time; the Canadian dollar may return to par with the U. S. dollar or even go below par, but this is the least important of the three factors.

Early increase in the westward movement of Canadian oil, then, will depend on the extent to which the recommendations of the Borden Royal Commission on Energy are implemented by the international oil companies serving the Pacific Northwest area. These recommendations were to the effect that the companies effect exchanges which would permit Canadian oil, via pipeline, to replace foreign or even some U. S. oil in Puget Sound.

The alternative is for Canada to embargo foreign oil in Eastern Canada and construct a pipeline from Alberta to Montreal. This at the present time is uneconomical and would result in many adverse reactions.

Trans Mountain's business in 1959 enabled the company to pay a modest dividend; it is expected that 1960 throughput will show a normal increase over 1959.

Growth Seen in Products Pipelines

William S. Spangler
Vice President
Humble Pipe Line Company

IN LOOKING AHEAD, let us first consider the demand for domestic petroleum. For many years, the petroleum industry has thought and planned in terms of a 5 percent annual rate of increase. In the coming years, the industry is likely to increase at a rate of only 3 percent a year. This slower growth in demand indicates that the capacity of crude oil lines in existence is generally adequate for the country's needs during the next ten-year period.

A similar conclusion was reached by a House Armed Services Subcommittee studying the adequacy of transportation system to support the national defense effort in the event of mobilization. The committee recently reported that the capacity of pipelines for expanded operations and production is unquestioned.

On the other hand, a products pipeline push is underway. This is, in part, the result of a wider acceptance of a new concept in the movement of petroleum products. In the past, pipelines carried large volumes and big batches. Now, with new techniques in handling, including automation, it has become possible to handle smaller batches efficiently. As a consequence, a greater variety of products can be moved through pipelines directly to distribution points.

The Committee for Oil Pipelines estimates that more than 20 percent of all refined products are being moved through pipelines. This percentage should increase in the coming decade. Some factors in this growth are expected to be liquefied petroleum gases, including butane and propane, petrochemicals, and jet fuel.

There has been increasing acceptance of LPG as an internal-combustion fuel on farms and in industry. In addition, its growing domestic use and its place in petrochemical production will mean faster and heavier deliveries.

Another growth factor will be the transportation of petrochemicals, such as ethylene, propylene, and benzene.

The third principal growth factor is products lines to serve airports. It appears that this market, and the jet age that fostered it, is only in the early stages of development.

A continuing problem, for at least the immediate future, seems to be the necessity for additional improvements in technology to help combat rising costs.

Accelerated Growth in Oklahoma

H. A. Eddins
President
Oklahoma Natural Gas Co.

WE ARE LOOKING forward to an acceleration in the industrial growth experienced in our territory in recent years. Last year sales of gas to industrial customers increased by 9 billion cu ft — twice the gain of the previous year.

The growing interest in the industrial development of Oklahoma is evidenced by the 56 industrial foundations which have been set up by communities within the state to attract new industry.

To keep pace with anticipated industrial growth and the growth in residential and commercial gas use which accompanies industrial expansion, we have estimated that we will make capital expenditures of approximately $10,000,000 during the coming year.

Complete Automation Not Yet Here

L. H. True
President
Magnolia Pipe Line Co.

AUTOMATIC OR centralized operation of pump stations is now common throughout the industry as the result of years of development and trial. The necessary tools for complete automation of pipelines, including computer control, however, still do not meet acceptable standards, particularly in terminal delivery operations. If the cost trends of the industry are to be maintained in the face of uncertain economic conditions, pipeline research and system engineering programs must be expanded.

Excluding natural gas lines, no major expansion of long haul pipelines can be foreseen in the near future. Increasing diversification of materials derived from petroleum will probably lead to construction of relatively short petrochemical pipelines in concentrated industrial areas. New operating and construction techniques must be fostered to economically transport these materials.

Hope To Begin Import Line In 1960

Norman R. Sutherland
President
Pacific Gas and Electric Co.

MUCH PROGRESS HAS been made during the past year in Pacific Gas and Electric Company's project to import natural gas from Alberta for distribution in California. It is hoped that all necessary governmental authorizations will be obtained in time to permit construction to start during 1960. The pipeline will be 36 in. in diam and 1404 miles long. Estimated total cost of the project is $338,000,000.

Hearings were begun during October before the California Public Utilities Commission on PG&E's application for authority to construct the 296-mile California section of the line, which will cost approximately $63,000,000. In the same month the Federal Power Commission held initial hearings on the application of Pacific Gas Transmission Company for a certificate to construct the 614-mile section extending from the United States-Canadian boundary to the California-Oregon boundary.

Also in October, hearings were held before the Alberta Oil and Gas Conservation Board on an amended application of the Alberta and Southern Gas Company, Ltd., of Calgary, a PG&E subsidiary, to authorize the export of 4.2 trillion cu ft of gas over a period of 25 years. The Conservation Board early in 1959 had authorized the export of 2.3 trillion cu ft. In this connection, the continued favorable trend of gas discovery in Alberta is encouraging.

January 5 has been set as the date for the commencement of hearings before the National Energy Board in Ottawa on the applications to export the gas from Canada and to build the inter-provincial pipeline.

The northern end of the project will be near the Athabaska River in Alberta. Traversing the Crowsnest Pass in southeastern British Columbia, the line will cross the international boundary near Kingsgate, B. C., then will be laid through the Idaho Panhandle, across Washington into Oregon, and thence south to Antioch in the San Francisco Bay area. Surveying of the route is well advanced.

Initially the system will transport about 180,000,000 cu ft of gas per day for delivery to others en route and will deliver a net of 415,000,000 cu ft per day to PG&E at Antioch.

Two underground gas storage facilities are being developed by PG&E, utilizing partly depleted natural gas fields. One is the McDonald Island field in the San Joaquin River delta and the other is the Pleasant Creek gas field near Winters in the Sacramento Valley.

Construction of 37.4 miles of 34-in. main and installation of additional compressor capacity at three compressor stations will be undertaken in 1960 if 100,000,000 cu ft per day of additional gas becomes available from the El Paso Natural Gas Company. Two applications by El Paso to supply this gas and another additional 100,000,000 cu ft, are pending before the Federal Power Commission.

Time to Look at Gathering Operations

H. D. Chrislip
General Manager
Pipeline Division
Kerr-McGee Oil Industries

OUR INTERESTS ARE principally in the crude and products end of the pipeline business. A broad look at this phase of the business indicates that we have a very adequate and efficient system of pipelines to serve this nation's needs. Some of these systems still require some degree of modernization. The level of activity in this area of work will probably be about the same as has occurred during the past year. To my mind there are only two exceptions to this general modernization pattern, which may result in substantial amounts of new construction:

1. Removal of Canadian crude from the import program is bound to have some effect upon the supply patterns to refiners in the Great Lakes area. It is a little early yet to determine what construction will result from this, but certainly there will be an expansion of facilities for delivering Canadian crude into the upper midwest.

2. There will be continued expansion in the construction of facilities for the handling of propane by pipeline. This will probably be split into two types of construction: (a) an increase in trunk line construction from source to large storage facilities in marketing areas not now served by pipeline, and (b) a greater development of small diameter lines to provide more competitive distribution from large storage areas.

Perhaps the most dramatic changes that will take place in our industry will be in crude oil gathering. The many technological improvements in the pipeline industry in the last ten years have had their primary application in trunk line operations. In reviewing the source of income of our large pipeline carriers this has been a rather logical application of these improvements since the bulk of the income producing ability of these carriers has been from trunk line movements. The high degree of efficiency now prevailing in the industry for trunk line hauls seems to indicate that the time has come to look at the smaller half of the pie.

In our search for new reserves in this country, more and more of our discoveries are in fields of rather limited geographic area, and this, coupled with the low producing rates prevalent in the U. S. today, makes new gathering line construction increasingly difficult to justify. Much of our supply in the old producing areas is shifting to secondary recovery methods of operation with the result that much of the existing facilities now require modification. To be able to serve properly this changing pattern of supply, we must streamline our gathering operations.

Pipeline companies, to this date, have only been lukewarm to the production segment of the oil industry's efforts to

streamline lease operations by the use of LACT. The key to the entire operation is the establishment of a successful continuous measurement system. With the pipeline companies' long experience in the field of measurement, and particularly in some of the new techniques now used in our most modern products pipeline, we must make a greater contribution toward the development of continuous measurement systems for gathering operations. This may be the year that the greater emphasis on this phase of crude oil pipelining begins to move.

Pipelines Tied to Population Growth

George S. Patterson
President
The Buckeye Pipe Line Co.

IT IS MY BELIEF that 1960 will usher in a trend toward greater economic growth and that oil pipelines will be directly affected. This growth will come as an immediate result of the need to supply the requirements of an ever-increasing population.

To be specific, I believe that emphasis in 1960 will be on the construction of additional refined products pipeline systems rather than on the construction of crude oil systems. There appears at this time to be sufficient crude oil pipeline capacity.

Buckeye looks forward to 1960 and to the years following with optimism. In 1959 Buckeye spent over $6,000,000 for new facilities and for improvements to existing facilities. We expect considerable growth in the economy during the next decade and will continue to strive toward full participation in the growth.

Industry Problem: Skilled Personnel

J. W. Emison
President
The Texas Pipe Line Co.

THE OUTLOOK FOR the pipeline industry during the year 1960 is one of gradual, but not extensive, increase in crude oil line capacity, with a somewhat faster expansion in products pipeline systems.

Most of the increase in crude pipeline capacity will be through additions of pumping equipment and construction of loop lines along systems now in service. Numerous projects for construction of new products pipelines or extensions to existing products lines are under consideration, and it is anticipated that pipeline construction activities in this field will surpass crude pipeline construction during the next two or three years.

Substantial progress has been made in the last five years in adapting automation equipment to pipeline operations, and we can expect increased improvements during the next five years. This has created an increased demand for technical personnel and more skilled field personnel to handle maintenance problems. One of the problems faced by pipeline management is to secure and train personnel qualified to handle such maintenance and to provide the advanced planning required for more modern methods of pipeline operation.

Assuming that there will be a gradual increase in domestic demand for crude petroleum and petroleum products in the United States over the next five years, we may expect normal construction activity in crude oil pipelines and above ordinary expansion in products pipeline systems.

Gas Will Meet Stiffer Competition

Paul Kayser
President
El Paso Natural Gas Co.

IN MY OPINION the natural gas industry is entering into a more mature stage in its development. The industry has certainly "come of age" and its problems in the future are going to be for men and not for boys. Gas is going to have to meet competition at the burner tip with all other fuels, and in fact, sources of energy.

However, in an economy such as that in the United States with a rapid population expansion and with improvement of uses by technology there is ample room for expansion, and I believe the industry will meet its problems and maintain the place it has built for itself in the economy to date and will expand to further usefulness as the economy expands.

It supplies a large percentage of the foundation of our standard of living — energy. So long as it furnishes energy efficiently and economically, the business will last certainly as long as the present high standard of living.

Pipelines Key in Energy Distribution

Orville S. Carpenter
President
Texas Eastern Transmission Corporation

INDUSTRIES SERVING THE primary energy fields will be faced with even greater challenges in coming years to maintain an expanding energy base for the nation's future requirements.

Demands will reach into all areas of primary power and the petroleum industry, for its part, will continue to face the problem of keeping up with end demand despite temporary recessions and setbacks.

Pipeline companies, as an integral part of the petroleum industry, will be playing an increasingly more important role as suppliers of energy to markets opened up by heavy anticipated population growth and increasingly higher levels of economic activity. While the industry has demonstrated over and over again its ability to keep supplies ahead of demand, the big problem is, as always, the development of a distribution network to funnel adequate supplies to the many points of consumption.

The problem will be compounded in years to come as energy requirements increase. Based on the combination of anticipated increases in gross national product and higher population, we foresee energy requirements increasing some 55 percent by 1970 and about 133 percent by 1980.

Texas Eastern's planned diversification and expansion program, which has transformed the company from an exclusive natural gas pipeline operation to a pipeline transporter of energy, was also an effort to fulfill its obligation to insure the nation's energy supremacy, principally by feeding new and growing markets.

This has been done by diversification of its interests with direction and with a new and tremendous concept in mind — pipeline transportation of energy. This course of action has provided us with a "pipeline of the future," scientifically designed and technically geared to take full advantage of the many avenues of growth available to the industry in the years to come. The petroleum industry has assumed leadership in the energy field and must continue as the leader. Its products are vital and versatile and what's more — economical. Its job is clear — to find new sources of

supply, produce them, refine them, transport them to the places where they are needed and distribute them to the ultimate consumer.

Pipelines are the silent but powerful servants who will play the key role in this picture.

Revenues About Like 1959

W. C. Kinsolving
President
Sun Pipe Line Co.

IN MY OPINION, 1960 will very closely follow the pattern of 1959 as far as the pipeline industry is concerned. No one knows yet what the outcome of the Taft-Hartley injunction will be regarding the steel situation. If a final settlement is not reached before the expiration of the injunction and the steel workers go out on another strike, no one can predict what the effect will be on our national economy. It is generally felt, however, that the Congress will not tolerate any resumption of a long strike.

The inventory situation continues to plague the oil industry and the only correction to this is a further curtailment of refinery runs. This, in turn, means reduced pipeline deliveries, so that I believe transportation revenues in 1960 will not be materially greater than they were for 1959.

As far as the expansion of pipeline facilities is concerned, there does not appear to be any demand for major crude lines in this country. There probably will continue to be further expansion of the products pipeline systems. It is now reported that the M-K-T Railroad is progressing with its proposed products system from Texas to the Middle West, and this may be a signal for future development of products lines by other railroads.

I think that major developments next year and for some time to come will be on automation. There remains much to be done along these lines, but I feel that it cannot develop too rapidly without a decided upsetting of the labor forces in the industry. In other words, automation can only proceed as fast as the displaced labor forces can be absorbed. Of course, automation can only be justified by the savings derived from reduced manpower.

I think that the pipeline industry, along with the oil industry, will continue to be harassed by those people in Congress who always seek personal agrandizement by using the oil industry as a whipping boy. Politicians of this type are always with us and we can expect them to continue their harassing tactics. I do not think, however, that there will be any real adverse legislation during the next year.

Summing all this up, I look for 1960 to be almost a repetition of 1959, both from an earnings and a capital investment standpoint.

Rising Costs Force Efficiency

R. K. Paine
Manager, Pipeline Dept.
Standard Oil Co.
of California

THE PIPELINE INDUSTRY has continued to expand and develop during the past year. Total pipeline construction mileage topped that of last year. Automation continued as pipeliners endeavored to keep pace with rising costs through more efficient operations.

The trend of more efficient operations through automation should continue during the coming year. Natural gas and products lines can be expected to lead in the construction scene—as our industry meets the demand in expanding marketing areas.

New Products . . . Facilities . . . Methods

M. E. Grant
President
Plantation Pipe Line Co.

THE SOUTHEASTERN STATES, through which Plantation Pipe Line Company operates, enters a new decade anticipating that industrial expansion will continue the healthy growth it experienced during the past decade.

Our own growth over the past decade is a good indicator of this region's growth. At the beginning of the Fifties, Plantation was prorating space to shippers with a single tube main line system of a 100,000-bbl per day capacity. As we go into the Sixties, the system has an input capacity at its initial station of 332,000 bbl per day with three parallel main lines originating at that point. In the year 1950, the system pumped 37.9 million bbl. For the year 1959, we anticipate the system will pump 104.8 million bbl. Our studies indicate that 1960 will show approximately a 5 percent increase in throughput over 1959.

An interesting development in 1959 was the movement of aviation products for commercial airlines. This new business, plus the handling of jet fuel and aviation gasolines for the U. S. Air Force, may amount to as much as 8000 bbl per day in 1960.

We have been impressed with the results of using electronic computers in scheduling and dispatching activities. Our two years' experience with this equipment was favorably reported on at the Fifth World Petroleum Congress, and this report has been well covered within the industry.

Large capacity turbine type meters have been installed at a number of places on the system and are giving good results. We are hopeful for the development of satisfactory instruments for batch interface detection.

At the end of 1959, nineteen shippers were using our system through 18 delivery points. These shippers increased their total storage during the year to 15.6 million bbl. Even more is needed, however, to minimize the seasonal fluctuations of shipments due to the heavy demands for distillates in the heating season.

No major expansion activities are being planned by us for 1960. We will however, continue in our efforts to recondition portions of our original system which were laid bare in 1941. We will also extend cathodic protection to the underground piping in our pumping stations and delivery terminals. Additional turbine meters are also scheduled for installation during the year.

Labor Costs May Trigger Automation

Harry G. Fair
President
Phillips Pipe Line Co.

WE FEEL THERE will be continued attention in the pipeline industry to cost reduction. The trend toward automation will continue. If labor costs increase, some automation projects which are now on the borderline economically will become feasible.

In the matter of oil pipeline transportation, it is our opinion that the crude oil volumes will remain static or possibly decrease slightly. Refined oil transportation will show a substantial increase following the trend of prior years.

We foresee no major expansion of crude oil carrying capacity in the United States next year. We believe some existing small diameter crude oil pipelines will be converted to refined oil service including natural gas liquid and LPG.

Heavy Equipment Whips Stubborn California Terrain

Route of Richfield's pipeline through Los Padres National Forest was steep, rocky, and tough

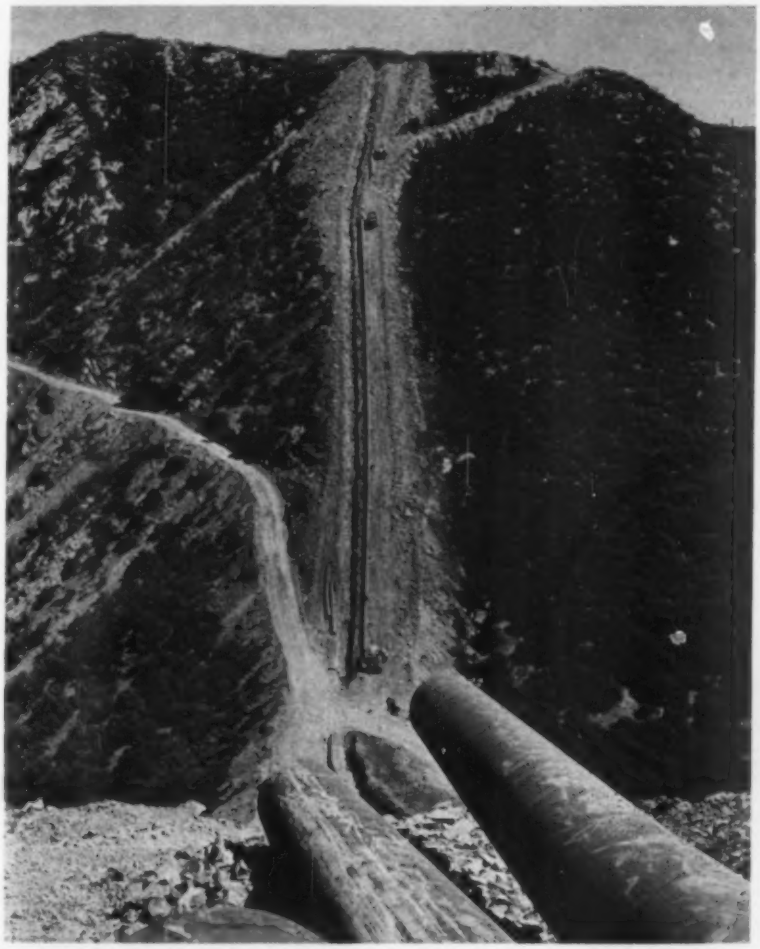
R. E. White, *Superintendent, Pipeline Department, Alex Robertson Company*

WHEN the final pig entered the scraper trap at the Southern California Edison Company's Mandalay steam plant near Ventura, California, natural gas for boiler fuel flowed through Richfield Oil Corporation's new 20-in. pipeline from the Cuyama Valley oil fields, some 58 miles to the north.

It was a welcome sight to the men of Richfield and of Alex Robertson Company, the contractor, who had fought the job through some of the roughest terrain in the western part of the country.

The job was started on the Cuyama Valley end by the first of four spreads, which covered the first 12 miles of the line in short order, the ground being fairly flat. At this point, however, was the Los Padres National Forest north boundary, where the mountains began, and became steeper, rockier, and tougher as the spread traveled south.

The second spread started shortly thereafter 45 miles to the south, near the National Forest south boundary, working north. The third spread started north of the city of Ventura in the Ventura oil fields, working north, and the fourth spread, handled by Ventura Pipeline Company on a subcontract, also started at this point working southward on the 5½ miles through the city of Ventura to the terminus at the Mandalay steam plant.



Winch tractor at top holds sideboom tractor as it brings double-joint down to be lined up.

Grades of 75 Deg

The heart of this job lay in the mountains of the National Forest where the slopes attained grades up to 75 deg for long distances and required heavy cuts, both sidehill and straightaway, which were further complicated by granite outcrops and ledges that had to be drilled and blasted. Where the right-of-way crossed over the top of White Ledge Mountain a cut of 80 ft deep was required to produce a grade that would allow men and equipment to work.

A total of about 75 tractors were used on the right-of-way clearing and grading operation, equipped with angle, straight, and U-blade dozers, and many with hydraulic rippers.

Much of Ditch Shot

Excavating trench through this country was as tough a problem as right-of-way grading, with a major portion requiring blasting to move the rock. A total of six wheel-type trenchers were used to excavate trench where the ground was suitable or to expose sections of rock and define areas to be drilled and shot. Ditch line was also ripped, using tractor-mounted hydraulic rippers where possible.

Drilling was handled by twin drills hung on side-boom tractors, with air

Over the top of White Ledge Mountain a cut 80 ft deep was made to produce a proper grade for men and equipment to work.

power supplied by 600 cu ft per min rotary compressors. Holes were loaded with 40 percent extra strength gelatin type powder and shot with electric caps, detonated with a hand-operated blasting machine. United States Forest Service requirements dictated the use of electric caps.

After the ditch line was shot, dozers dressed up the area and ¾-yard crawler backhoes dug out the rock. A total of 18 backhoes were used in this operation.

Tractors equipped with towing winches were used to pull all trenching equipment up the steep slopes with as many as four winch tractors required to hold and pull a backhoe up some of the extended grades.

Fire Precautions Strict

Requirements of the U. S. Forestry Service to minimize the possibility of starting a forest fire in the dense brush, scrub oak, manzanita, and "Buck Thorn," which covered the entire area involved a great deal of work and expense. Access roads and helicopter landing areas were built at specified locations; water tankers and fire fighting tool caches were spotted along the route; all equipment was fitted with effective exhaust spark arresters; fire breaks were constructed adjacent to the right-of-way.

A representative of the U. S. Forestry Service was assigned to patrol the work of each spread with the authority to shut down any or all operations if atmospheric conditions indicated an extreme fire hazard. On eight separate occasions operations were ordered suspended for all or part of the working day, due to the combination of high temperatures and low relative humidity with any degree of wind.

All U. S. Forestry Service men were cooperative and helpful in completing the job under these conditions, and fully appreciative of the value of the 50-ft wide, continuous, cleared right-of-way strip, together with some 20 miles of new access roads through a portion of the National Forest where previously there was no access.

The remaining construction operations were all proportionately as tough as the right-of-way and trenching.

Pipe Hauled 400 Miles

Pipe was hauled by trucks some 400 miles from the fabricating plant at Napa, California, before it hit the right-of-way and was then transferred to dollies and towed to the right-of-way by tractors and unloaded and strung with sidebooms.

The ditch was measured, angles shot, and pipe was bent to fit, using a vertical hydraulic bending machine. The pipe, in 40-ft joints, would allow for a maximum bend of about 26 deg in a single joint, and for mile after mile a bend of some degree was required in practically every joint.

Welding generators for stringer beads and hot pass welds were mounted directly on tractors, which could negotiate most of the slopes or be winched when required. Mounted on these same tractors was a compressor that supplied the air to operate pneumatic internal lineup clamps, which were used to good advantage, especially on the extremely steep slopes. Firing line generators were mounted on sleds and towed along the line by tractor.

Pipe Tape Wrapped

Pipe was received bare and was cleaned and wrapped over the ditch with a polyethylene tape and an outer wrap of 15-lb rag felt. This operation was performed by a traveling, combination cleaning and wrapping machine, and the pipe was cradled into the ditch directly out of the machine.

Here again the steep slopes and the rock complicated the operation and as many as six sideboom tractors were needed on a string of pipe to cradle the machine, control the movement of the pipe, and hold the string in place until it was anchored in the ditch.

Approximately 95 percent of the pipeline had to be shaded with select material prior to final backfill. This operation was handled by track mounted skiploaders and hand labor, with suitable rock free material hard to find on most areas. Earth filled sacks were placed across the ditch to prevent backfill erosion.

Final right-of-way clean up involved the disposal of brush and grading for drainage control.

Three Rivers Crossed

Three river crossings included in the job presented no particular construction problems. The pipe sections were welded into strings, coated with a double wrap of tape and felt, which were covered with a 2-in. thick reinforced "Gunited" concrete coating and lowered in. The Santa Clara River crossing, approximately 2000 ft in length, required a system of well points to handle ground water during pipe installation. The Ventura River and the Cuyama River had very little surface flow and ground water was no problem.

Finally the completed pipeline was tested with gas to a pressure of 1050 psi on the north 40 miles through the mountains, and hydrostatically to a maximum pressure of 1415 psi on the remainder. The line was purged using a slug of nitrogen ahead of the gas.

Maintenance a Big Job

To service and maintain the great spread of equipment on this project was a full scale job in itself. Two master mechanics directed a force of some 20 mechanics and service men whose job was as tough as the rest of the operations.

The job was organized and managed through two project offices, one in the Cuyama Valley and the other in Ventura, California.

Operations of the construction force, which reached a maximum of about 500 men, were directed by Alex Robertson Company's project managers Kenneth Pratt and Bob White. Individual spread superintendents included Jake Cheeves, Frank Sutton, Al Beasley, and Ted Drewry. Richfield Oil Corporation's force of engineers and inspectors was headed by Bob Frazier.

★ ★ ★

Pipeline Engineer's

1960 Pipeline Contractors Directory

Here is an up-to-date listing of both general and specialized pipeline contracting companies. Given are the firm names, addresses, telephone numbers, and chief contact in each company, as furnished by the companies themselves. Listed first are those firms that do general pipeline contracting. Specialized firms are listed on succeeding pages.

A

APV Company, Inc.
1801 Continental Natl. Bk. Bldg.
Fort Worth, Texas
Phone: EDison 2-3397
A. "Pup" Vaughn, Pres.

A. G. Ainsworth, Jr., Inc.
Box 168
Luling, Texas
Phone: TRiangle 5-2510
A. G. Ainsworth, Jr., Pres.

J. W. Albrecht Constr. Co.
214 S. Main
Bridger, Montana
Phone: 5505
J. W. Albrecht, Pur. Agt.

E. K. Aldridge & Sons, Inc.
Box 1324
Athens, Ga.
Phone LIberty 6-6470
R. G. Aldridge, Gen. Mgr.

Altgelt Construction Co., Inc.
3502 Lawrence Dr.
Box 1402
Corpus Christi, Texas

Andrews-Parker, Inc.
Box 927
Bryan, Texas
C. L. Andrews, Pres.

Apache Contractors, Inc.
823 McBirney Bldg.
Tulsa 3, Okla.
Phone: LUther 2-9848

Arey Pipe & Constr. Co., Inc.
Box 1501
Pampa, Texas
Phone: MO 4-7487
R. E. Arey, Pres.

Ashy Construction Co., Inc.
Box 472
Eunice, La.
Phone: GLendale 7-2294
M. Ashy, President

B

B & M Constr. Co.
2808 First Natl. Bldg.
Oklahoma City, Okla.

Banister Helm Ltd.
625 Northern Hardware Bldg.
Edmonton, Alta., Can.
Phone: 4-8147
A. E. Helm, Pres.

Barbarossa and Sons, Inc.
St. Cloud, Minn.
Phone: BL 1-7821
Gordon F. Barbarossa, Pres.

Barry Construction Co.
Box 185
Pearland, Texas
Burt Barry, Pres.

C. P. Bartley & Son
Box 616
Tioga, North Dakota
Phone: 4-3476
C. P. Bartley, Sr., Pres.

Bill Baum General Contractor, Inc.
716 E. Mesa
Gallup, N. M.
Bill Baum, Pres.

Bechtel Corporation
220 Bush St.
San Francisco 4, Calif.
Phone: DO 2-4032
S. D. Bechtel, Pres.
S. D. Bechtel, Jr., Exec. V.P.

Bennett Line Constr. Co.
3906 Ave. R.
Lubbock, Texas
Oscar B. Bennett, Jr., Owner

Berry Construction Co.
Box 88
New Hebron, Miss.

O. O. Berryhill
Box 3277
Temple, Texas

C. W. Blakeslee & Sons, Inc.
58 Waverly St.
New Haven, Conn.
Phone: UN 5-4135
W. T. Gilbert, Pres.

Brodie Construction Co.
Box 2646
Amarillo, Texas
Phone: DRake 2-7928
J. T. Brodie, Owner

Brown & Root, Inc.
4100 Clinton Drive
Box 3
Houston, Texas
Phone: FAirfax 3-7121
L. E. Minor, V.P., Mgr. P/L Dept.

Buchanan Contracting Co., Inc.
Box 1903
Birmingham, Ala.
P. A. Buchanan, Pres.

O. R. Burden Construction Corp.
6702 East 21st St.
Box 5216
Tulsa, Okla.
Phone: TEmple 8-3378
O. R. Burden, Pres.

Buttram Pipe Line Constr. Co.
Box 744, Airport Rd.
Ponca City, Okla.
Phone: ROgers 5-4421, 5-4422
James W. Buttram, Pres. & Pur. Agt.

C

Campbell P & H Co.
1252 Houston St.
Mobile, Ala.

Canadian Bechtel Ltd.
25 King St. W.
Toronto 1, Ont., Can.
Phone: EMpire 2-3261
S. M. Blair, Pres.

Canadian Comstock Co., Ltd.
206 Laird Drive
Toronto, Ont., Can.
Phone: HU 1-3461
C. I. Rathgeb, Jr., V.P., Mgr. Dir.

Cape Construction Co.
Box 423
Cape Girardeau, Mo.
Phone: EDgewater 5-8204
R. B. Potashnick, Pres.

Clay P. Carey Co., Inc.
Box 832
Brownwood, Texas
Phone: 2-8344
Clay P. Carey, Pres. & Pub. Rel.

Chambliss-Kirksey, Inc.
Box 218
Sweeny, Texas
Phone: 2285
J. V. A. Kirksey, Pres.

Cheek Construction Co.
Ulysses, Kansas
Phone: FL 6-1448
Troy Cheek, Owner

W. E. Claycomb and Son
Route 1
Cody, Wyoming
Phone: 1494 or 783
W. E. Claycomb, Pres.

Colorado and Wyoming Constr. Co.
Box 357
Loveland, Colorado
Phone: 7-3505

Condux, S. A. de C. V.
P. Suarez Sur 446, Desp. 303
Monterrey, Mexico
Phone. 2-4378
Humberto Lobo, Pres.

Conner Construction Co.
Box 1047
Odessa, Texas
Phone: FEderal 7-7367
Jack A. Conner, Pres.

Consolidated Construction Co.
Box 505
Carthage, Texas
Phone: OX 3-6631, 3-6632
J. L. Bunyard, Owner

Construction Service Co.
Box 311
Bound Brook, N. J.
Phone: ELliot 6-2790
J. J. Senesy, Pres.

Contracting & Material Co.
1235 Dodge Ave.
Evanston, Ill.
Phone: BRoadway 3-2500
W. P. Cagney, Jr., Pres.

Crain Bros. Inc.
Grand Chenier, La.
Phone: JE 8-2180
J. P. Crain, Pres.

Cumberland Contracting Co., Inc.
Box 515
Monticello, Ky.
Phone: FIlmore 8-3411

A. J. Curtis & Co.
Box 111
Hickory, Pa.
Phone: ELgin 6-2226
A. J. Curtis, Pres.

D

D. B. S. Pipeline Constr. Corp.
2903 Spruce St.
La Grande, Oregon
Phone: WOodland 3-3217
D. B. Shrum, Pres., Gen. Supt.

Mitchell Darby Constr. Co.
610 E. Beaumont St.
Box 160
McAllen, Texas
Phone: MU 6-2463, 2464
Mitchell Darby, Owner

George W. Davis Constr. Co.
1414 N. Eastern
Box 6072
Oklahoma City, Okla.

Dixie Construction Co., Inc.
Box 1286, Oil Center Sta.
Lafayette, La.
Phone: CE 4-8501
J. W. Lambert, Pres.

Doerfler-Krapff Corp.
2514 S. Agnew
Oklahoma City, Okla.
Phone: ME 4-1454
L. M. Doerfler, Pres.
W. E. Krapff, V. P.

S. W. Downer, Jr., Inc.
31 N. Main St.
Glassboro, N. J.
S. W. Downer, Jr., Pres.

Dutton-Williams Bros., Ltd.
North Canadian Oil Bldg.
Calgary, Alta., Can.
Phone: AMherst 6-8601
M. A. Dutton, Pres.

E

Eastern Pipe Line Contractors
820 Mercantile Bk. Bldg.
Dallas, Texas
Phone: RIverside 1-4081
C. Hobson Dunn, Owner

East Penn Construction Co.
Lancaster County
Landisville, Pa.

A. J. Ellis Constr. Co., Inc.
Box 98
College Park, Maryland
Phone: WEbster 5-3000
A. James Ellis, Pres., Treas.

Engelking & James Ltd.
408A 16th Ave., N.E.
Calgary, Alta., Can.

Engineers Limited Pipeline Co.
11858 San Pablo Ave. (Gen. Off.)
El Cerrito, Calif.
Phone: LAndscape 4-6464
Roy Price, Ch. of Bd.
J. C. Howe, Jr., Pres.

Enterprises Edouard Denys, S.A.
18 Avenue Clementine
Ghent, Belgium
Edouard Denys, Pres.

R. C. Ernst
Box 168
Evans City, Pa.

Eubanks & Smith PL Constr. Co.
Rt. 2, Box 470
Greenville, Miss.
Phone: 5464
J. D. Eubanks, Co-Owner
J. L. Smith, Co-Owner

F

Fabricas Protexa, S.A.
Apartado No. 1141
Monterrey, N.L., Mexico
Phone: 6-2800
Humberto Lobo, Pres.

L. E. Farley, Inc.
Texas Gas Bldg.
Box 6841
Houston 5, Texas
Lloyd Farley, Jr., Pres.

E. E. Farrow Co.
Box 13186
Dallas 20, Texas
Phone: RIverside 1-4048
E. E. Farrow, Managing Partner

Ferguson Construction Co.
Box 127
Eunice, N. M.

Fisher Contracting Co.
2201 S. 19th Ave.
Box 6306
Phoenix, Ariz.

C. N. Flagg & Co., Inc.
48 Elm St.
Meriden, Conn.
Phone: BEverly 7-5581
Peter Flagg, Pres.

Flint Rig Co.
705 Midland Bk. Bldg.
Billings, Montana
Phone: 3-3086
C. N. McCarty, Pres.

C. S. Foreman Co.
1900 Armour Rd.
North Kansas City, Mo.
C. S. Foreman, Pres.

Four Way Co, Inc.
Box 695
Aztec, N. M.
Phone: FEderal 4-6222
Russell Anderson

Foutz & Bursum Constr. Co.
Box 307
Farmington, N. M.
J. L. Foutz, Pres.

George W. Fowler Contractor
Box 5561
Bossier City, La.
Phone: 4-0932
George W. Fowler, Owner

Fowler-Tatom Pipeline Contr., Inc.
Box 368
Cotton Valley, La.
Phone: VE 2-4264
C. Wayne Fowler, Pres.

Fulghum Contracting Corp.
Box 1181
Harrisburg, Pa.
James T. Fulghum, Pres.

Fulton-Banister, Ltd.
625 Northern Hardware Bldg.
Edmonton, Alta., Can.
Phone: GA 4-8147
R. K. Banister, Pres.

R. H. Fulton & Co.
2323 Erskine Rd.
Box 1526
Lubbock, Texas
Phone: POrter 3-4376
R. H. Fulton, Owner

G

G. E. T. Constr., Inc.
435 S. 116th St.
Milwaukee, Wisc.
Phone: GLenview 3-9000
L. F. Beaver, Pres.

Gaasch Construction Co.
Box 386
Brownfield, Texas
Phone: 2560
Phil Gaasch, Owner

Gabe's Construction Co.
2019 N. 10th St.
Sheboygan, Wisconsin
Phone: GLencourt 8-2194
George Gabrielse, Partner
John Gabrielse, Partner
Edwin Gabrielse, Partner
John Hermann, Partner

General Construction Co.
Box 195
Clendenin, W. V.

Gene's Welding & Pipeline Constr.
Box 468
Ft. Morgan, Colorado
Gene Babcock, Owner

Geneva Construction Co.
111 Downer Pl.
Aurora, Ill.
Phone: Twin Oaks 2-4357, 2-4358
G. N. Bryan, Pres.

H. L. Gentry Construction Co.
921 East Michigan
Jackson, Mich.
Phone: STate 9-6192
H. L. Gentry, Pres.

George Consolidated
Box 8305
3816 Fannin
Houston, Texas
Phone: JA 6-3153

Glaser Construction Co., Inc.
Drawer 1387, Oil Center Sta.
Lafayette, La.
Phone: CE 5-1551
D. M. Glaser, Owner

Golightly Construction Corp.
6450 Liberty Rd.
Box 15243
Houston, Texas
Phone: ORchard 2-0561
W. L. Golightly, Pres.

Grayco Constructors, Inc.
1201B West 34th St.
Box 4147
Austin, Texas
Phone: HOmestead 5-8797
Jack S. Gray, Pres.

Gray-Morrison Contractors, Inc.
Box 4086
Austin, Texas
Phone: HOmestead 5-8797
Jack S. Gray, Pres.

Great Lakes Dredge and Dock Co.
228 N. LaSalle St.
Chicago 1, Ill.
E. K. Lydon, Pres.

J. W. Green Contractors
Box 248
Overton, Texas
Phone: 4851, 3521
Billy Utsey, Mgr.

Gregg Construction Co.
Box 886
Longview, Texas
William D. McMahon, Owner

Groninger & King, Inc.
Box 1381
Pampa, Texas
Phone: MO 4-3351
L. M. McCathern, Pres.

Gulf Welding & Machine Works
Conroe, Texas
B. L. "Buddy" Sherrod, Owner

Gustine Construction Co.
603 West Main St.
Ardmore, Okla.
Phone: 5963
D. F. "Curly" Gustine, Owner

H

H & K Construction Co.
Box 1053
Sinton, Texas

H. F. & L. Contractors, Inc.
Hwy. 25 South
Box 278
Amory, Miss.
Phone: CLearbrook 6-3572
James E. Hathcote, Pres., Gen. Supt.
Marlin R. Fikes, V. P.
Mrs. Curtis W. Lewellen, Off. Mgr.

Hahn Contracting Co.
Box 38
Birdsboro, Pa.
Phone: JUniper 2-8372
A. L. Price, Pres.

B. C. Hall Constructors, Inc.
Box 644
Aztec, N. M.
Phone: FEderal 4-6137
B. C. Hall, Pres.

Hall Construction Co.
Box 1004
Liberal, Kansas

The Hallen Constr. Co., Inc
4270 Austin Blvd.
Island Park, N. Y.

Hallmac Construction Co.
3701 Buffalo Dr.
Houston, Texas
Phone: JAckson 6-1377
James W. Hall, Pres.

Ham Construction Co.
Box 12132
Houston, Texas
Phone: MI 4-0108
C. M. Ham, Owner

Hanna Construction Co.
9000 Airport Blvd.
Houston 17, Texas
Phone: HUdson 4-2220
Fares K. Hanna, Pres.

Harbert Construction Corp.
Box 1369
2208 8th Ave. S.
Birmingham, Ala.
Phone: ALpine 1-0256

Harford Brothers
P. O. Box 191
Emporia, Penn.
R. E. Harford, Pres.

Luther G. Harper Constr. Co.
6645 N. Peoria
Tulsa, Okla.
Phone: Filmore 5-1226
Luther G. Harper, Owner

A. W. Hartwig, Inc.
301 Fratt Bldg.
Billings, Montana
A. W. Hartwig, Pres.

Hebert Bros. Engineers
Box 448
Plaquemine, La.
Phone: 3189
Hiram Hebert
Omer J. Hebert
Roy A. Hebert

Hemphill Contracting Co.
4317 - 32nd
Lubbock, Texas
Phone: SWift 9-0156
O. F. Hemphill, Pres.

Henuset Brothers, Ltd.
Box 657
Virden, Manitoba, Can.
Phone: 612
Henry Henuset, Pres.

A. C. Holder Constr. Co., Inc.
2410 N. Lewis
Box 8616, Springdale Sta.
Tulsa, Okla.
Phone: Gibson 7-5233

Holder Constr. Co., Inc.
Box 1438
Snyder, Texas
C. O. Holder, Pres.
C. O. Holder, Jr., V. P.
T. W. Holder, Secy-Treas.

Hood Construction Co.
Box 2167
Los Nietos, Calif.
B. M. Laulhere, Pres.

Hood Northwest Pipeline Co.
Box 1082
Tacoma 1, Wash.
Phone: WAverly 6305
B. M. Laulhere, Jr., Pres.

Ralph Hopple
1727 - 19th St., N.E.
Canton 4, Ohio
Phone: GL 4-4319
Ralph Hopple, Owner

Houston Contracting Co.
2807 Buffalo Speedway
Houston 6, Texas
Laurence H. Favrot
Geo. A. Peterkin
R. P. Gregory

H. B. "Buster" Hughes, Contr.
Box 55
Harvey, La.
Phone: FO 6-6461
H. B. "Buster" Hughes, Partner
H. D. "Sonny" Hughes, Partner

M. L. Hulcher Co., Inc.
Box 168 Virden, Ill.
Phone: 5091
Melvin L. Hulcher, Pres.

I

E. A. Irish, Contractor
2944 Gleneden St.
Box 39701, Griffith Sta.
Los Angeles 39, Calif.
Phone: NOrmandy 3-2127
Wm. E. Irish, Pres.

V. T. Irons Machinery Co.
2618 W. Division
Arlington, Texas
Phone: Fort Worth, JE 4-3275
V. T. Irons, Owner

J

Jackson Pipe Line Constr. Co.
Box 455
Clendenin, W. Va.
Phone: LIberty 3-2771
John B. Jackson, Pres.

Jalco, Inc.
3816 Fannin St.
Houston, Texas
Phone: JA 3-8177

L. H. James Constr., Ltd.
408A - 16th Ave., N.E.
Calgary, Alta., Can.
L. H. James, Pres.

Roy L. Johnson Constr. Co.
Box 484
Eldorado, Kansas
Phone: 1303 or 531
Roy L. Johnson, Owner

Johnson-Western Constructors
2031 E. Belt St.
Box 2588
San Diego 12, Calif.

Joyce Pipeline Co.
Box E
Andover, N. Y.
Phone: 2626
James Joyce, Owner

Joyce Western Corp.
Box E
Andover, N. Y.
Phone: 2626
James Joyce, Owner

K

K-F-B Construction Corp.
611 Sklar Bldg.
Box 1775
Shreveport, La.
Phone: 2-9424 or 5-2491
F. S. Kelly, Jr., Pres.

Kaighen & Hughes Constr. Co.
Box 27
Mill Creek, W. Va.
Frank Morrison, Supt.

B. Keillor Co., Ltd.
53 Middlecrest
Ancaster, Ont., Can.
Phone: Miller 8-4934
Ben Keillor, Pres.

Knupp Construction Co.
Box 152
Great Bend, Kansas
H. V. Knupp, Pres.

Roy E. Knupp Co.
East Highway No. 40 — Box 495
Russell, Kansas
Phone: HUdson 3-3675, 3-4722
Box 251, Great Bend, Kansas
Phone: GLadstone 3-5665
Roy E. Knupp, Owner

Koller Construction Co.
Box 29, Dularge Route
Houma, La.
Earl R. Koller, Pres.

The Kuljian Corp.
1200 N. Broad St.
Philadelphia 21, Pa.
Phone: CEnter 2-9000
Harry A. Kuljian, Pres., Bd. Ch.

L

Laco Pipeline Contractors, Inc.
2120 S. Post Oak Rd.
Box 22047
Houston 27, Texas
Phone: MOhawk 7-6647
W. G. Lewis, Pres.

Wade Lahar Constr. Co.
9219 E. Admiral Pl.
Tulsa, Okla.
Phone: TEmple 5-9561
Wade Lahar, Pres.

Lake Construction Co.
Box 516
Sour Lake, Texas
Phone: ATlas 7-3631
William H. Watts, Pres.

Lasley Construction Corp.
Box 1465
Hobbs, N. Mex.
M. W. Lasley, Owner

Latex Constr. Co. of Ga.
Box 12128
Atlanta, Ga.

Laurel Ridge Constr. Co.
234 W. Pittsburgh St.
Greensburg, Pa.
Phone: 4814
T. R. McCartney, Pres.

C. S. LeNoir Constr. Co.
Box 798
Austin, Texas
Charles S. LeNoir, Pres.

I. C. Little Constr. Co., Inc.
1108 Fidelity Union Life Bldg.
Dallas 1, Texas
Phone: RIverside 7-5781
I. C. Little, Pres.

Lock Construction Co.
Box 3136
Midland, Texas
L. H. Lock, Pres.

W. M. Lyles Co.
Box 495
Avenal, Calif.
Phone: AVenal 222
W. M. Lyles, Pres.

M

M. G. M. Construction Co.
Box 1056
Concord, Calif.

M-R Company
5317 W. Harry St.
Box 484
Wichita 1, Kansas
Phone: WHitehall 3-7951
Myrl Rumsey, Owner

Macco Corporation
14409 S. Paramount Blvd.
Paramount, Calif.

Majestic Contractors Ltd.
49 Jackes Ave.
Toronto, Ont., Can.
Phone: WAlnut 5-3443
W. A. Rose, Pres.

Mannix Co., Ltd.
737 - 8th Ave., S.W.
Calgary, Alta., Can.
Phone: AMherst 6-7361
W. F. Sharon, Exec. V. P.

Marine Pipeline & Dredging, Ltd.
2256 W. 12th Ave.
Vancouver 9, B. C., Can.
Phone: REgent 6-9231
D. J. Baldwin, Pres., Gen. Mgr.

Mary Construction Co., Inc.
Box 423
Cape Girardeau, Mo.
Phone: EDgewater 5-8204
R. B. Potashnick, Pres.

H. B. May Pipe Line Constr.
Wichita Natl. Bk. Bldg.
Wichita Falls, Texas
Phone: 322-7992

O. W. Mayfield Contracting Co.
701 N.E. 2nd, Box 663
Andrews, Texas
Phone: LA 3-3322
O. W. Mayfield, Owner

Frank McCoy Constr. Co., Inc.
Box 273
Carbondale, Pa.
Frank C. McCoy, Pres.

McCutchen Construction Co.
1426 Elton Rd.
Jennings, La.
Phone: 668 and 669
V. B. McCutchen, Owner

McDace Co., Inc.
26440 W. Eight Mile Rd.
Detroit 41, Mich.
Phone: KEnwood 3-5040
George McDace, Pres.

McDace, Ltd.
Box 610
Byron, Ont., Can.
Phone: Byron 656
William L. McDace, Pres.
Joseph M. McDace, Mgr.

Henry C. McDonald Co.
Box 1032
Kilgore, Texas
H. C. McDonald, Owner

J. L. McFadden Pipe Line Contr.
Box 12362
Houston, Texas
Phone: HUdson 6-7244
J. L. McFadden, Owner

H. A. McGinnis Constr. Co.
Box 5
Dumas, Texas
Phone: WE 5-2017
H. A. McGinnis, Pres.

McKenzie Constr. Co., Inc.
Box 301
Lock Haven, Penn.
Phone: Woolrich, Pa.,
POrter 9-6474
Fred McKenzie, Pres.

McLaughlin, Inc.
Box 1824
Great Falls, Montana
J. L. McLaughlin, Pres.

McVean and Barlow, Inc.
Box 151
Odessa, Texas
Phone: FE 7-2377
J. A. McVean, Board Chrmn.
A. K. Barlow, Pres.

Meadows Southern Constr. Co.
Rt. 4, Box 396A
Orlando, Fla.
Phone: CRestwood 7-3221-2
Kenton Meadows, Owner

Mermis Construction Co.
Box 1017, Artesia, N. M.
Phone: SHerwood 6-2852
Alfred Mermis, Owner

Merritt-Chapman & Scott Corp.
260 Madison Ave.
New York 17, N. Y.
Phone: ORegon 9-3500
Robert E. Harvey, Pres.
Wm. Denny, Exec. V.P., Constr. Dept.

Mid-Mountain Contractors, Inc.
1310 Airport Way
Seattle 4, Wash.
Phone: MUtual 2146
F. E. Everett, Jr., Pres.,

Mid-States Construction Co.
Box 417
Mt. Vernon, Ill.
Phone: 5245
O. A. Holdren, Pres.

Midwestern Contractors, Inc.
130 W. Liberty Dr.
Wheaton, Ill.
Phone: MOntrose 8-3420
A. T. Everham, Pres.

Miller Brothers, Contractors
3302 So. 4th St.
Abilene, Texas
Phone: ORchard 4-7932
L. C. Miller, Partner
J. W. Miller, Partner
V. E. Miller, Partner

Don W. Miller, Inc.
211 Euclid St.
Green Springs, Ohio
Phone: 3061
Don W. Miller, Pres.

Mitchell Construction Co.
301 W. 53rd St. N.
Wichita, Kansas
Phone: TEmple 8-6141
Vernon E. Mitchell, Pres.

Mitchell Constr. Co., Inc.
Box 1745
Farmington, N. M.
Phone: DAvis 5-5722
J. L. Mitchell, Pres., Gen. Mgr.

Roy M. Mitchell Contracting Co. Inc.
1621 W. Claude St.
Tyler, Texas
Roy M. Mitchell, Pres.

Modern Welding Co.
1500 East Twelfth St.
Box 528
Owensboro, Ken.
Phone: MUrray 3-5323
Wesley Embry, Mgr. P/L Div.

Monarch Constructors, Inc.
Box 3266
Odessa, Texas
G. F. Smith, Pres.

M. L. Moore Construction Co.
Box 1444
Odessa, Texas
Phone: FE 2-1484
M. L. "Jack" Moore, Owner

G. G. Morgan, Pipe Line Contr.
Box 112
Decaturville, Tenn.
Glen Morgan, Owner, Gen. Supt.

Morrison Constr. Co., Inc.
1834 Summer St.
Hammond, Ind.
Phones: WEstmore 2-5036
Chicago, Ill., SAginaw 1-7036
J. M. Morrison, Pres.

Morrison-Knudsen Co., Inc.
319 Broadway
Boise, Idaho
Phone: 4-3521
H. W. Morrison, Pres., Bd. Ch.

Morrison-Shivers, Ltd.
1011 San Jacinto Street
Box 1076
Austin, Texas
Phone: GReenwood 8-1611
Allan Shivers, Ch. of Bd.
E. G. Morrison, Pres.

P. L. Murphy Constr. Co.
106 S. Clinton St.
Dwight, Ill.
Phone: 25
P. L. Murphy, Owner

Bill Murry and Co.
Rt. 5, Box 367-M
Beaumont, Texas
Phone: TErminal 5-6372
Bill Murry, Pres.

N

Narramore Construction Co.
Drawer 38
Maysville, Okla.
Phone: 7-4444
Marvin Narramore, Owner

Natchez Contracting Co.
Rt. 4, Box 275, Morgantown Rd.
Natchez, Miss.
J. C. Campbell, Owner

J. P. Neill & Company Inc.
522 Meadows Bldg.
Dallas, Texas
Phone: EMerson 8-4631
James P. Neill, Pres.

L. F. Nichols Constr. Co.
Box 376
Great Bend, Kansas
Phone: GLadstone 3-5772
L. F. Nichols, Owner

H. H. Null Pipeline Contractors
215 Lockwood Dr.
Houston 11, Texas
H. H. Null, Pres.

O

O'Connor Construction Co.
Fromberg, Montana
Phone: 6500
Geo. W. O'Connor, Pres.

Ohio Pipe Line Constr. Co.
1635 W. Church St.
Box 29, Newark, Ohio
Phone: Dlamond 4-4125, 4-3535

Oil Field Service Co., Inc.
Box 656
Tioga, N. Dakota
Phone: MOhawk 4-3311
C. E. Pratt, Gen. Mgr.

Oklahoma Contracting Co.
6612 Harry Hines Blvd.
Dallas, Texas
Phone: FLeetwood 1-3711
T. A. Hester, Pres.

Oliphant Construction Co.
3328 E. Main St.
Lafayette, Ind.
Phone: GI 7-5359
D. A. Oliphant, Pres.

Otis Eastern Service, Inc.
Box 435
Bolivar, N. Y.
Phone: 690
John A. Thompson, Pres.

P

P & M Construction Co.
361 Dickman Rd.
Battle Creek, Mich.
Phone: WO 3-3738
Leroy T. Pearson, Pres.

Pacific Pipeline Constr. Co.
1632 S. Greenwood Ave.
Montebello, Calif.

Panama, Inc.
1801 Tennessee Bldg.
Houston 2, Texas
Phone: CApital 4-6105-6-7
R. G. Rice, Pres.

Panama Williams Corp.
1418 Melrose Bldg.
Houston, Texas
Phone: CApitol 5-3507
M. S. Williams, Pres.

Paramount Constructors, Inc.
Box 3266
Odessa, Texas
W. W. Teer, Pres.

The Parsons Co.
Box 1071
Alice, Texas
Phone: MO 4-6465
C. B. Pinkston, Field Supt.

Patterson and Ford Constr. Co.
2717 - 31st Ave. N.
Birmingham, Ala.
Phone: 4-3112
G. L. Patterson, Partner
John D. Ford, Partner

Pease Bros.
Hotel Vernal Bldg.
120 E. Main St.
Vernal, Utah
Phone: 527, 567, 783
R. W. Pease, Pres.
W. L. Pease, Partner

Penn-Jersey Pipeline Constr. Co.
Foot Industrial Ave.
Little Ferry, N. J.
Phone: Dlamond 2-4660
Robert S. Gates, Pres.

A. T. Perry Pipe Line Constr., Inc.
Riverside Station
Kansas City 50, Mo.
A. T. Perry, Pres.

Pierce Construction Co.
Box 3115
Tulsa, Oklahoma
Phone: WEbster 6-8757
Jay Pierce, Owner

Piggott Construction Ltd.
608 Renfrew, Rideau Towers
Calgary, Alta., Can.
J. A. Piggott, Pres.

Pioneer Construction Co.
1300 Oak St.
Chattanooga, Tenn.

Pipe Line Constr. & Drlg. Co.
Box 165
Camp Hill, Penn.

Pipe Line Maint. & Constr. Co., Inc.
Box 56
Camp Hill, Penn.

Pipeline Service Co.
540 W. Strother
Box 32
Seminole, Okla.

Poston Corp.
621-622 Metropolitan Bldg.
Akron 8, Ohio
Phone: JEfferson 5-1915, 5-4749
Jack O. Poston, Pres.

R. B. Potashnick
Box 423
Cape Girardeau, Mo.
Phone: EDgewater 5-8204
R. B. Potashnick, Owner

Prairie Construction Co.
Box 1526
Lubbock, Texas

Preston Clarke, Ltd.
Box 461
Edmonton, Alta., Can.
Phone: HOmestead 6-5402
S. Preston, Pres.

H. C. Price Co.
Price Tower
Bartlesville, Okla.
Phone: FEderal 6-8000
Harold C. Price, Pres.

Ted Price Construction Co.
Box 72 Electra, Texas
Ted Price, Pres.

R

Steve P. Rados, Inc.
112 W. Maple St.
Monrovia, Calif.

Ramey Contracting Co., Inc.
Box 182
1215 N. Alder
Bellaire, Texas
Phone: MOhawk 7-2143
Roy A. Ramey, Owner

Reason Construction Co.
3045 W. Liberty Ave.
Pittsburgh 16, Penn.

R. J. Reid Contracting Co.
2109 N. 14th St.
Box 1990
Birmingham, Ala.
Phone: FA 2-4729
John T. Benton, Owner

R. E. Reutzel Co.
Box 15
Fremont, Neb.
Phone: PArk 1-1603
R. E. Reutzel, Pres.

Richards & Associates, Inc.
Box 88
Carrollton, Ga.
Phone: TE 2-7001
Roy Richards, Pres.

River Construction Corp.
4837 W. Freeway
Box 9127
Fort Worth 7, Texas
Phone: PErshing 8-6518
Robt. Thomas, VP & Gen. Mgr.

Robb Construction Co., Ltd.
1237 Albert St.
Regina, Sask., Can.
Phone: JO 9-9505
George R. Robb, Pres.

Alex Robertson Co.
14433 Paramount Blvd.
Box 757
Paramount, Calif.
Phone: NEvada 6-1225,
MEtcalf 3-1191
Alex Robertson, Pres.

C. L. Rogers Construction Co., Inc.
1114 City Natl. Bldg.
Box 1706
Wichita Falls, Texas
C. L. Rogers, Pres.

Ross-Powers Constr. Co.
1131 N. Thirtieth St.
Box 2038
Billings, Montana
Phone: 9-2038
Grady T. Ross, Partner

Phillip Rusher Pipeline Constr.
730 E. 18th St.
Owensboro, Ky.
Phone: MU 3-1215
Phillip Rusher, Owner

S

N. A. Saigh Co.
Suite 531, Majestic Bldg.
San Antonio 5, Texas
Phone: CApitol 5-2933
N. A. Saigh, Owner

O. G. Sanders & Son Contractors
Box 3176 Waco, Texas

San Juan Basin Constr. Co., Inc.
Box 2116
Farmington, N. M.
Phone: DA 5-6632
J. W. Powell, Pres.

Shamrock Construction Co.
1804 W. Saginaw St.
Box 1177
Lansing, Mich.

H. S. Shanks & Son
Box 175
Alice, Texas
Phone: MOhawk 4-7893

Sharman, Allen, Gay & Taylor, Inc.
3115 Buffalo Dr.
Box 13152
Houston, Texas
Phone: JAckson 6-1841
J. W. Sharman, Pres.

F. E. Shaw, Ltd.
215 Markham Rd.
Richmond Hill, Ont., Can.
Phone: AVenue 5-4955
J. M. Cunningham-Dunlop, Pres.

Shawver and Hailey
Box 1127
Maud, Okla.

Sheehan Pipe Line Constr. Co.
514 Natl. Bk of Tulsa Bldg.
Tulsa, Okla.
R. D. Sheehan, Mng. Partner

Sheppard-Geiger Constr. Co.
Box 2098
Corpus Christi, Texas

F. L. Showalter, Inc.
2900 Fulks St.
Lynchburg, Va.
Phone: VIctor 5-2388
F. L. Showalter, Sr., Pres.

Simpson Construction Co.
Box 1186
Sterling, Colorado
Phone: LA 2-1063
B. G. Simpson, Pres.

Slade & McElroy, Inc.
2105 25th Ave.
Box 255
Gulfport, Miss.
Phone: UNiversity 3-4022
Preston Slade, Pres.

Carl E. Smith, Inc.
Box 4
Sandyville, W. Va.
Phone: Ravenswood
BRowning 3-4261
Carl E. Smith, Pres.

Smith Contracting Corp.
R. F. D. No. 6, Box 211
Fort Worth, Texas
Phone: VInewood 2113
O. R. Smith, Pres.

Snelling Company
La. Hwy. 1 and Old Pine Hill Rd.
Shreveport, La.
Phone: 2-8731
J. F. Snelling, Co-owner
W. D. Snelling, Co-owner

Somerville Construction Co.
6648 Fulton Rd.
Ada, Mich.
Phone: ORiole 6-4611
R. B. Somerville, Pres.

Robert B. Somerville Co., Ltd.
4126 Bathurst
Toronto, Ont., Can.
Phone: MElrose 3-4264
Robert B. Somerville, Pres.

Stanley-Bledsoe Corp.
612 Daniel Bldg.
Tulsa 3, Okla.
C. C. Bledsoe, Pres.

Stelco, Inc.
905 Barton Springs Rd.
Austin, Texas
S. C. Hill, V. P.

Sterling Construction Co.
Box 1186
Sterling, Colorado
Phone: LA 2-1063

Stockton Constr. Co., Inc.
2205 Peach Tree
Amarillo, Texas
Phone: FL 6-1421
S. G. Stockton, Pres.

Stone & Webster Const. Co., Inc.
Box 550
Salem, Va.
Phone: DU 9-2421

Stuart Pipe Line Constr. Co.
Box 790
Beeville, Texas
Phone: FL 8-1515
Burley Stuart, Owner

Sullivan, Long & Hagerty
2028 Second Ave.
Bessemer, Ala.
Phone: HA 8-2355
Charles A. Long, Sr., Pres.

Sweazy Construction, Inc.
Box 565
Ulysses, Kansas
Phone: FLanders 6-1610, 6-1630
Fred M. Sweazy, Pres.

Swift Current Constr., Ltd.
Box 878
Swift Current, Sask., Can.
W. A. (Bill) Burton, Pres.

Swilling & Boyd Contractors
Box 96
Whitney, Texas
R. T. Swilling, Jr., Partner

T

T - T Construction Co.
Box 817
Tomball, Texas
Phones: SWift 5-2536
CApitol 8-1747, Houston
T. T. Moore, Pres.

Tarnow Pipeline Constr. Co., Inc.
Box 96
Kansas, Ill.
Phone: YE 8-2031
N. M. Tarnow, Pres.

Texas Engineering & Constr. Co.
723 N. Grand
Box 1203
Amarillo, Texas
Phone: DR 2-1325

Texas-Louisiana Contractors
Box 9127
Fort Worth 7, Texas
Phone: PErshing 8-6518
Robert Thomas, Partner

Joe Titsworth
Box 1539
Kilgore, Texas
Phone: 3230

Trojan Construction Co., Inc.
Box 270W
Oklahoma City 12, Okla.
Phone: WH 9-5626
Felix M. Johnson, Pres.

Troth Construction Co.
Box 8696
Oklahoma City, Okla.

Troy Construction Co.
4840 Holmes Rd.
Houston, Texas
Phone: RE 3-4333
Troy Dacus, Pres.

Tulsa Contracting Co., Inc.
Box 4235
East Providence, R. I.
Phone: GE 4-7521, GE 4-7510
Andrew G. Admire, Pres.

U

Union Construction Co.
Box 57
Sturgis, Ky.
Phone: 3542
I. C. Russell, Jr., Pres.

Universal Engineers & Constrs., Inc.
Box 5216
Tulsa, Okla.
O. R. Burden, Pres.

Universal Pipeline Constrs., Inc.
251 Union Sta.
Kansas City 8, Mo.
Phone: VI 2-2393
R. F. Pitman, Pres.

V

Vaughn & Taylor Constr. Co., Inc.
Box 3266
Odessa, Texas
Phone: EM 6-3656
D. D. Vaughn, Pres., Gen. Supt.

Vedal Pipe Line Constr. Co.
Rt. 5 Salem Rd.
Mount Vernon, Ill.
Phone: 4400
E. C. Veach, Pres.

Ventura Pipeline Constr. Co.
899 N. Olive St.
Box 1252
Ventura, Calif.

Roy Vickers Lease Service
Box 648
Robstown, Texas
Phone: 3179
Roy Vickers, Pres., Field Off. Mgr.

Virginia Pipe Line Constr. Corp.
Box 156 Hampton, Va.

W

Leroy L. Wade & Son, Inc.
1615 Izard St.
Omaha 2, Neb.
Phone: WEbster 0600
Leroy L. Wade, Pres.

J. L. Williams Constr. Co., Inc.
Box 164, 6114 Edgemoor
Bellaire, Texas
Phone: GYpsy 4-4251
J. L. Williams, Pres.

C. E. Wilson Constr. Co.
3718 W. 95th St.
Kansas City 15, Mo.
Phone: MItchell 9-8811
C. E. Wilson, Owner

Winger Construction Co.
1200 E. Main St.
Ottumwa, Iowa

Wirt & Starn, Inc.
736 W. Liberty St.
Wooster, Ohio
Phone: ANgelus 3-4731
Paul Wirt, Pres.

Wonderly Construction Co.
2694 Lime Ave.
Long Beach 6, Calif.
Phone: GArfield 7-8945,
NEvada 6-3184
M. C. Wonderly, Pres.

Wyoming Ditching Service
Box 176
Osage, Wyo.
Phone: INgersol 5-2294

Karl B. Wagner Engr. Constr., Inc.
Box 4515
Austin, Texas
Phone: HO 5-7671
Karl B. Wagner, Owner

Wavco, Inc.
Box 105
Morristown, Tenn.
Lee Vaughan, Pres.

L. E. Webb Construction Co., Inc.
Box 705
Santa Maria, Calif.
Phone: WAlnut 5-2481
L. E. Webb, Pres.

Welded Construction Co., Inc.
Rosebush, Mich.
Phone: GE 3-2281
Harold Fluharty, Pres.

Western Pipe Line, Inc.
Box 1076
Austin 66, Texas
Phone: GR 8-1611
E. G. Morrison, Pres.

Western States Constr. Co., Inc.
Box 4502
Oklahoma City, Okla.
Phone: OR7-3033, OR 7-6222
H. D. Kelly, Pres.

White Ditching Co., Inc., of Wyo.
Box 39
Casper, Wyoming
Phone: 3-3783
H. H. Hayman, Pres.

Harvey B. White, Ltd.
Box 158
Windsor, Ont., Can.
Harvey White, Pres.

M. E. White Constr. Co., Inc.
Box 441
McPherson, Kansas
Phone: 261
Paul R. White, Co-Owner
Robert D. White, Co-Owner

Jess Whitlow Pipe Line Service
Box 1844
Ponca City, Okla.
Phone: ROgers 5-5876
Wilkie Contracting Co.
Box 447
Claysville, Penn.
Phone: NOrmandy 3-7747
O. W. Wilkerson, Pres.
Williams Bros. Co.
326 Natl. Bk. of Tulsa Bldg.
Tulsa 3, Okla.
Phone: LUther 5-9161
John H. Williams, Pres.

Y

J. E. Young Pipe Line Contr., Inc.
931 E. Rosecrans Ave.
Los Angeles 2, Calif.
Phone: NEvada 6-2293
J. E. Young, Pres.
L. R. Young Construction Co.
Box 372
210-A W. Main
Salem, Ill.
Phone: SAlem 193

Z

H. B. Zachry Company
Pipe Line Constr. Div.
Box 10188
San Antonio 21, Texas
Phone: WAlnut 2-1213
Larry O. Cox, Div. Mgr.

Specialized Contractors

Listed below are names, addresses, and chief contact of those firms doing specialized contract services such as coating and wrapping, river crossings, marine pipeline construction, X-ray inspection, etc.

A

Abrams Aerial Survey Corp.
606 E. Shiawassee
Lansing 1, Mich.
Phone: IVanhoe 2-6271
Ralph E. Kauffman, Pres.
Aerial Surveys
Aerial Line Patrol
7721 Satsuma Ave.
Sun Valley, Calif.
Phone: POplor 4-8366
Joseph S. Pryzbylo, Owner
Aerial Survey
Pipeline Patrol

Aerial Patrol Service Corp.
Box 5274
Tulsa 16, Okla.
Phone: TEmple 5-6332
Culver NeSmith, Pres.
Aerial Survey
Pipeline Patrol

Aero Exploration Co.
Box 7068
Tulsa, Okla.
Fred Q. Casler, Pres.
Aerial Survey
Pipeline Patrol
Aerial Photo for
Right-of-Way Location

Aero Service Corp. (Mid-Continent)
1401 S. Detroit
Tulsa, Okla.
Phone: GI 7-9159
A. E. Ibach, V. P.
Aerial Surveys

American Dewatering Corp.
140 Cedar St.
New York, N. Y.
E. J. Moore, Pres.
River Crossing Dewatering
Dewatering Wet Soil

American Pipe Coating Contr., Inc.
Box 89 Jennings, La.
Phone 2599
Lewis A. Wheeler, Jr., Pres.
Coating and Wrapping
Reconditioning and Beveling
Railhead Jobs

Anchor-Wate Co.
3609 McHard Rd.
Almeda, Texas
Phone. IDlewood 3-2461
L. B. DuLaney, Pres.
Coating, Wrapping

Anchor-Wate, Ltd.
108A - 8th Avenue, W.
Calgary, Alta., Can.
Phone: AMherst 9-2167
C. L. Wilson, V. P., Gen. Mgr.
Coating, Wrapping

Arthur Bros., Inc.
Box 792
Kingsville, Texas
Phone: LYric 2-6416
C. L. Arthur, Pres.
Station Construction
Welding

Asbury Transportation Co.
2222 E. 38th St.
Los Angeles 58, Calif.
Phone: ADam 4-9261

Atlantic Gulf & Pacific Co.
15 Park Row
New York 38, N. Y.
Phone BArclay 7-8370
H. F. Schoon, Pres.
Marine Dredging

Ayres Welding Co.
Box 124
Holliday, Texas
Phone: 2441
C. D. Ayres, Partner
Joe D. Ayres, Partner
Welding

B

Arthur Ball Drainage & Constr. Co.
Box 105
Libertyville, Ill.
Phone 2-3708
Arthur L. Ball, Jr., Owner
Ditching
Barnard & Burk Pipeline Engineering, Inc.
1023 Nicholson Dr.
Baton Rouge, La.
Chas. C. Barnard, Pres.
Jack S. Burk, V. P.
Engineering, Construction
C. F. Bean, Inc.
Box 335 Plaquemine, La.
C. F. Bean, Pres.
Marine Dredging
Bell Transportation Co.
1406 Hays
Houston, Texas
Phone: FAirfax 3-4361
Mrs. J. Harold Bell, Pres.
Stringing and Hauling
M. L. Bennett & Son Constr. Co.
809 Ryan St.
Owosso, Mich.
Phone: SAratoga 3-4521
M. L. Bennett, Pres.
Ditching
Bigge Drayage Co.
Box 67
San Leandro, Calif.
Phone NEptune 8-8100
H. W. Bigge, Pres.
Stringing, Hauling
Boring & Tunneling Co. of Am.
Box 14214 2902 Ricks Rd.
Houston 21, Texas
Phone: JAckson 6-2755
Gilbert Turner, Partner
Bill Horner, Partner
Road Boring
Briner Rust Proofing Co., Inc.
Box 984
Albuquerque, N. M.
Pipe Protection
Wayne Broyles Engineering Corp.
4401 Navigation
Houston, Texas
Phone: FA 3-6858
Wayne E. Broyles, Pres.
Engineering
Buck Mountain Constr. Co.
3653 Rohnerville Rd.
Fortuna, Calif.
Phone RAndolph 5-2191, 5-3620
George P. Lennon, Partner
Uno T. Sundberg, Partner
Right-of-Way Clearing

H. E. Burger
Box 755
Eagle Lake, Texas
Phone: CEdar 4-3165
H. E. Burger, Pres.
Right-of-Way Clearing, Grading

C

Camco Construction Co., Inc.
Box 2127
Fullerton, Calif.
Phone: MA 6-8319
V. A. Mickelberry, Pres.
Station Construction

Campbell, McLeod & Campbell, Ltd.
11220 - 151st St.
Edmonton, Alta., Can.
Phone: HUdson 9-1084
R. M. McLeod, Secy. Treas.
Road Boring, Stringing

Canadian-Parkhill Pipe Strg., Ltd.
21 King Street E. — Rm. 411
Toronto, Ont., Can.
Phone: EM 3-3671, EM 3-0828
Roy F. Parkhill, Pres.
Stringing and Hauling

Sam Carline, Inc.
Box 138
Berwick, La.
W. D. Schoolcraft, Gen. Supt.
Pipeline Construction
Offshore Construction
Marine Dredging

Central X-Ray, Inc.
1725 Levee
Dallas, Texas
X-Ray Inspection

Centriline Corp.
140 Cedar St.
New York 6, N. Y.
W. E. Borbonus, Pres.
In Place Cement Lining

Chicago Bridge & Iron Co.
332 S. Michigan Ave.
Chicago 4, Ill.
Engineering Services, Fabrication
Station Construction, Tanks

Clear Span Structures, Inc.
4118 Fannin St.
Houston 4, Texas
Weldon F. Appelt, Pres.
River Crossings

Coates Field Service, Inc.
Box 1581
4800 N. Santa Fe
Oklahoma City, Okla.
Phone: JA 8-7578
John J. Coates, Pres.
Right-of-Way Acquisition and Services
Title Experts and Damage Claim Settlement Specialists

Collins Construction Co.
Box 86
Port Lavaca, Texas
Phone: JA 4-3771
S. V. Collins, Owner
Marine Pipeline Construction

Cor-Bin, Inc.
Box 35037
Houston 35, Texas
Hydrostatic Testing
Radiographic Inspection

Valton Cowser Welding Contr.
Box 1
6349 Highway 9
Corpus Christi, Texas
Phone: TUlip 4-5342
Valton Cowser, Owner
Welding, Beveling

V. Cowser Rd. Crossing Contr., Inc.
Box 1
6349 Highway 9
Corpus Christi, Texas
Phone: TUlip 4-5342
Valton Cowser, Pres.
Road Boring

J. L. Cox & Son, Inc.
9721 E. 63rd St.
Raytown 33, Mo.
Phone: FLeming 3-1092, 3-2042
Leroy Cox, Pres.
Stringing and Hauling

Syd E. Culbertson Co., Inc.
Box 9186 Houston 11, Texas
Phone WAlnut 6-8803
Syd E. Culbertson, Pres.
Pipe Coating and Wrapping
Hydrostatic Testing, Welding
Stringing, Hauling, Pipe Storage
Barge Terminal Facilities

D

R. G. Dalious Constr. Co.
5935 S. Peoria
Tulsa, Okla.
Phone: RIverside 7-7373
R. G. Dalious, Partner
C. C. Dalious, Partner
Stations, Terminals

W. A. Dorris, Contractor
1726 Hunter Lane
Corpus Christi, Texas
Phone: TU 4-5003
W. A. Dorris, Owner
Hydrostatic Testing

Dravo Corp.
Dravo Bldg.
Pittsburgh, Pa.
Pipe Fabrication

Dresser Engineering Co.
Box 2518
Tulsa, Okla.
Phone LUther 7-2411
L. L. Dresser, Pres.
Design, Station Construction

Dudley Construction Co.
Box 4
Joseph, Utah
Right-of-Way Clearing, Grading

Art Duff Welding Service
209 4th Ave.
Big Rapids, Mich.
Welding

Dunbar & Sullivan Dredging Co.
2312 Buhl Bldg.
Detroit 26, Mich.
Phone: WO 1-2333
E. D. Wattles, Pres.
Marine Dredging
Marine Construction

Dunn Brothers, Inc.
801 Mercantile Securities Bldg.
Dallas, Texas
Phone: RIverside 8-5221
Stringing and Hauling

E

Ebasco Services Inc.
2 Rector St.
New York 6, N. Y.
Phone: Digby 4-4400
Offices in: Chicago; Dallas; Portland, Oregon; San Francisco; Washington, D. C.
Engineering, Construction and Business Consulting Services

Jess Edwards, Inc.
Drawer 1091
Corpus Christi, Texas
Phone: TUlip 3-8441
Glenn Alexander, Pres.
Stringing

Elliott Marine Divers
Box 5512, Drew Station
West Prien Lake Rd.
Lake Charles, La.
Phone: GReenfield 7-5011
H. A. "Larry" Elliott, Owner
Marine Services
Ditching and Excavating
Marine Construction
Complete Inspection

Engineers Limited Pipeline Co.
11858 San Pablo Ave. (Gen Off.)
El Cerrito, Calif.
Phone LAndscape 4-6464
Roy Price, Ch. of Bd.
J. C. Howe, Jr., Pres.
Station Construction

Essco, Inc.
1610 First Natl. Bk. Bldg.
Dallas 2, Texas
Phone: RIverside 2-5983
Don L. McCarty, Pres.
Hydrostatic Testing

Dick Evans, Inc.
Box 2384
Wichita, Kansas
Phone: AMherst 5-6291
Dick Evans, Pres.
Right-of-Way Maintenance

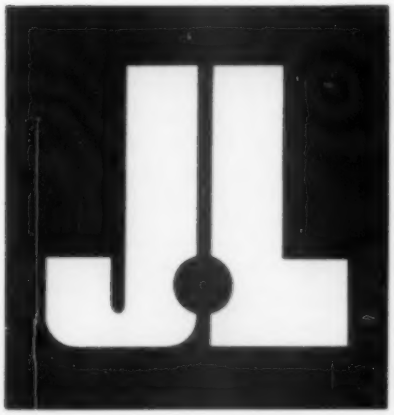
F

Fabricas Protexa, S.A.
Apartado No. 1141
Monterrey, N.L., Mexico
Phone: 6-2800
Humberto Lobo, Pres.
Coating, Wrapping

Superior quality 12¾" O.D. J&L Electricweld line pipe was used for 17 miles of this Northern Oklahoma Gas Company line from Cherokee to Ponca City. The line will serve the towns of Ponca City, Perry and Newkirk, Oklahoma, and area industries. J&L line pipe is available in sizes from 6⅝" to 12¾".

General Contractor:
O. R. Burden Construction Corporation, Tulsa, Oklahoma
Contractor for coating and wrapping:
Secrest Pipe Coating Service, Tulsa, Oklahoma

Pipe laying operations with this J&L Electricweld line pipe are fast and efficient. Weldability is excellent. Pipe is 29.28 pounds per foot, .219" wall, X-46 grade.



Reliable field performance is assured because every length of J&L pipe undergoes a specified hydrostatic pressure test which proves its dependability under sustained and surge pressures.

This ultrasonic tester provides immediate pictures of weld soundness in all J&L Electricweld line pipe. It is one of the most advanced control devices in pipe-making.

Quality control at J&L pays off on a job at Cherokee

Every length of J&L line pipe passes over 50 quality tests before it enters the field

Total quality control of J&L Electricweld line pipe is maintained through more than 50 control measures and tests on every length of pipe.

Crush tests assure weld strength and steel quality. A modern ultrasonic device probes soundness of the weld. All joint ends are magnafluxed to assure freedom from flaws. Every length is full-pressure tested under specified A.P.I. or A.S.T.M. hydrostatic test requirements, both in time and degree of pressure. These are a few of the stringent controls that assure complete dependability of J&L Electricweld line pipe.

It pays to specify plant-tested, field-proved J&L Electricweld pipe for your transmission, distribution or gathering lines. Write for J&L's new bulletin.

Jones & Laughlin Steel Corporation

PITTSBURGH, PENNSYLVANIA

Fairchild Aerial Surveys, Inc.
224 E. 11th St.
Los Angeles 15, Calif.
Phone: RI 9-3007
E. M. Day, Pres.
Aerial Surveys

Fenix & Scisson, Inc.
5808 E. 15th St.
Tulsa, Okla.
Phone: TEmple 5-4459
S. E. Scisson, Pres.
Engineering Services
Cavern Excavating

The Fish Engineering Corp.
796 M & M Bldg.
Houston, Texas
Phone: CA 5-5311
C. B. Ames, Pres.
Engineering, Construction

Fish Northwest Constructors, Inc.
796 M & M Bldg.
Houston, Texas
R. D. Ricketts, Pres.
Engineering Services
Pipeline and Station Constr.

Fluor Corp., Ltd.
2500 S. Atlantic
Box 7030
Los Angeles 22, Calif.
Phone: ANgelus 2-6111
J. S. Fluor, Pres.
Engineering Services
Station Construction

Foor Engineering Co.
Box 691
Oklahoma City 1, Okla.
Phone: ME 4-3122
P. A. Foor, Pres.
Station Construction

Ford, Bacon & Davis Constr. Corp.
3901 Jackson St.
Box 1762
Monroe, La.
Phone: FAirfax 3-2281
Charles C. Whittelsey, Pres.
Engineering and Construction

D. A. Foster Trenching Co.
Box 38
Merrifield, Va.
Ditching

G

Samuel Gallucci & Sons, Inc.
102-11-44th Ave.
Corona, Long Island, N.Y.
Phone: HIckory 6-3100
Victor Gallucci, Pres.
River Crossings

Garrett Construction Co.
Box 2227
Corpus Christi, Texas
Phone: TU 4-1638
A. C. Garrett, Owner
Marine Construction

Gasoline Plant Constr. Corp.
253 Esperson Bldg.
Houston 2, Texas
Phone: CA 2-0302
M. H. Kotzebue, Pres.
Station Construction
Gasoline Plant Design, Constr.
Petrochemical Plants

Gates Bros. Marine Contrs., Inc.
Foot Industrial Ave.
Little Ferry, N. J.
Phone: DIamond 2-4660
Robert S. Gates, Pres.
River Crossings
Meter Station Constr.

General Aerial Surveys, Inc.
Box 4525
Tulsa, Okla.
Phone: RIverside 2-8179
Hurshel E. Wallace, Pres.
Aerial Surveys & Mapping

Gil Gillespie, Marine Diver
5061 Sumrall
Baton Rouge, La.
Phone: ELgin 7-6854
Gil Gillespie, Owner
Marine Construction
Marine Inspection

Goodwin Engrs. of the South, Inc.
2111-7th Ave., S.
Birmingham, Ala.
Phone: FAirfax 2-6535
J. W. Goodwin, Pres.
Engineering Services

Graver Construction Co., Inc.
424 Madison Ave.
New York 17, N. Y.
S. D. Barr, Gen. Sales Mgr.
Engineering
Station Construction

Graves Well Drilling Co.
Box 225
Sylacauga, Ala.
Phone: CHapel 5-4213, 5-4124
E. L. Graves, Partner
J. D. Smith, Partner
River Crossings

Gulf Coast Pipe Coating Corp.
Box 2091
Houston, Texas
Phone: JAckson 6-1505
T. A. Morgan, Pres.
Coating, Wrapping

Gulf Consultants
8301 Lockheed
Houston, Texas
Offshore Wind and Wave Action
Soil Analysis

Gulf Interstate Co.
1125 Brazos St.
Houston, Texas
Phone: CApitol 8-8201
Hy Byrd, Pres.
Engineering Services

H

Tom Hafer Co.
5320 Maple
Bellaire, Texas
Right-of-Way
Ditching, Backfilling
Clean Up and Road Boring

Harford Bros. Pipe Stringing Corp.
Box 191
Emporium, Pa.
Phone: 358, 732, 743
R. E. Harford, Pres.
Stringing

John J. Harte Co.
284 Techwood Drive, N. W.
Atlanta, Ga.
Phone: JA 5-4502
David J. Hogg, Pres.
Consulting Engineers

O. L. Harvey Truck Service
Box 192 Seminole, Okla.
Phone: 184
O. L. Harvey, Owner
Hauling and Stringing

Heavy Haulers, Inc.
Box 267
Dallas 21, Texas
Phone: RI 1-3481
Ben F. Thurmond, Pres.
Stringing

Helm Equipment Co., Ltd.
625 Northern Hardware Bldg.
Edmonton, Alta., Can.
Phone: GA 4-8147
Jim Boyce, Gen. Supt.
Coating

Hill-Hubbell and Co.
3091 Mayfield Rd.
Cleveland 18, Ohio
Coating and Wrapping

R. N. Hodges Welding Co.
Rt. 1, Box 146
Conroe, Texas
Phone: PL 6-8761
R. N. Hodges, Owner
Welding

Holden Construction Co.
Box 496
Pawhuska, Okla.
Phone: 889, 864
Wiley J. Holden, Jr., Owner
Pump Stations, Terminals
Compressor Stations

Hood Flexible Pipe Cleaning Co.
Box 2167
Los Nietos, Calif.
B. M. Laulhere, Pres.

Mike Hooks, Inc.
Box 135
Lake Charles, La.
Phone: HE 6-5951
M. A. Hooks, Pres.
Marine Construction

Houston Gamma Ray Co.
5412 Schuler
Box 19093
Houston, Texas
Phone: UN 9-2444
Thomas E. Ketchbaw, Pres.
X-Ray Inspection

Houston Road Boring Co.
Box 9653
Houston 15, Texas
Phone: GL 3-4953
F. O. Warburton, Pres.
Road Boring

Huddleston Engineering Co.
Box 998
Bartlesville, Okla.
Phone: 2767
William E. Huddleston, Pres.
Engineering

Hudson Engineering Corp.
2711 Danville
Houston, Texas
Phone: JA 9-4261
John B. Baird, Pres.
Engineering
Station Construction

Huffman-Wolfe Southern Corp.
Box 1248 Atlanta 1, Ga.
Welding, Fabricating,
Radiography

Joe D. Hughes, Inc.
Box 2143
Houston, Texas
Stringing and Hauling
Unloading and Storing
Barge Shipments

Hunsaker Trucking Contractors, Inc.
11476 Harry Hines Blvd.
Dallas, Texas
Phone: CHapel 7-3155
Box 97
Carrollton, Texas
R. B. Hunsaker, Pres.
Stringing and Hauling

Hunt Process Co., Inc.
2046 E. Dominguez St.
Long Beach 10, Calif.
Phone: SPruce 5-1586
Coating, Wrapping

I

Indust. Gamma-Ray & X-Ray Labs.
Box 992
Norristown, Pa.
Radiographic Inspection

Industrial Welding & Testing Lab.
224 Hamilton St.
Houston, Texas
Phone: CA 4-6925
Bryan J. Norwood, Gen. Mgr.
X-Ray Inspection
Field Stress Relieving
Magnaflux and Zyglo Inspection

Industrial X-Ray Engineers
115 Belmont Ave., N.
Seattle, Wash.
Phone: EAst 3-0620
C. E. Boucher, Pres.
X-Ray Inspection

Irish Engineering Service, Inc.
2504 Flournoy-Lucas Rd.
Shreveport, La.
Phone: ME 5-2188
L. B. Irish, Pres.
Coating and Wrapping

Irish Engineering Serv. of Ark., Inc.
Box 44
Little Rock, Ark.
Phone: MOhawk 4-1509
L. B. Irish, Pres.
Coating, Wrapping

J

J & J Welding Service
Box 7
Waskom, Texas
Phone: MUrdock 7-3483
Welding

J. C. Johnson Dredging Co.
510 Chronicle Bldg.
Houston, Texas
Phone: CApitol 4-1837
J. C. Johnson, Owner
Marine Construction

K

Keith Kote, Inc.
Box 928
Grand Prairie, Texas
Phone: AN 2-1527, 2-5197
Coating and Wrapping

The M. W. Kellogg Co.
711 Third Ave.
New York City, N. Y.
Phone: OXford 7-5200
Warren L. Smith, Pres.
Engineering, Station Constr.

Knapp Construction Co.
Box 177
Oxford, Kansas
Phone: 109
Charles W. Knapp, Owner
Take-Up

L

Archie Lacy
2401 Bleker
Houston, Texas
Phone: CA 7-7922
Archie Lacy, Pres.
Stringing

Lamar & Harrison
815 N. Third
Lufkin, Texas
Phone: NE 4-7212
J. E. Harrison, Pres.
Right-of-Way Clearing, Grading

Paul A. Lambert
Simmesport, La.
Box 188
St. Francisville, La.
Phone: 1802
Right-of-Way
Ditching and Excavating
Marine Dredging

Russell Lasater Constr. Co.
813 W. 61st St.
Odessa, Texas
Phone: Emerson 6-5021
Russell Lasater, Pres.
Plant and Station Construction

Latex Constr. Co. of Ga.
Box 12128
Atlanta, Ga.
Station Construction

Law Engineering Testing Co.
136 Forrest Ave.
Atlanta, Ga.
Phone: TR 5-6601
George H. Nelson, Pres.
X-Ray Inspection

Loftin & Woodard, Inc.
503 W. First St.
Delhi, La.
Phone: TRojan 8-3727
Right-of-Way Clearing, Grading

Logan Diving & Salvage
305 Consolidated Bldg.
Jacksonville, Fla.
Phone: EL 6-3473
C. F. Logan, Partner
J. E. Logan, Partner
Marine Engineering
Marine Construction
River Crossings
Contract Maintenance

Longview Equipment Co.
Box 2767
Monroe, La.
Station Construction

Luke Construction Co., Inc.
210 Van Ave.
Houma, La.
Phone: UP 2-3549
Luke E. Grezaffi, Pres.
Right-of-Way Clearing, Grading
Road Boring

M

Mayes Bros., Inc.
1150 McCarty Dr.
Box 2062
Houston 1, Texas
Phone: OR 2-7566
H. Boyd Mayes, Pres.
Coating and Wrapping

Mayes, Clem A., & Son
Box 764
1300 Commercial St.
Lake Charles, La.
Phone: HEmlock 3-5252, 3-5253
Clem A. Mayes, Partner
Dolen G. Mayes, Partner
Coating, Wrapping,
Reconditioning

McAlinden Construction Co.
86 E. Prospect St.
Hopewell, N. J.
J. A. McAlinden, Pres.
Marine Construction
Marine Blasting

J. Ray McDermott & Co., Inc.
Box 38, Harvey, La.
2nd Fl., Saratoga Bldg.
New Orleans 12, La.
W. J. Benton, Pipeline Eng.
Marine Dredging
Marine Construction

McWilliams Dredging Co.
Box 584
New Orleans 7, La.
Phone: AMherst 5371
L. R. Thornton, Pres.
River Crossings, Dredging

Merritt-Chapman & Scott Corp.
260 Madison Ave.
New York 17, N. Y.
Phone: ORegon 9-3500
Robert E. Harvey, Pres.
Wm. Denny, Exec. V.P., Constr. Dept.
Engineering Services

Midsouth Coating Corp.
Box 118, Shively Br.
Louisville 16, Ky.
Phone: SPring 4-4352
A. L. Allbritton, Supt.
Coating and Wrapping

Eldon Miller, Inc.
Box 232 Iowa City, Iowa
Phone: 8-1123
Eldon Miller, Pres.
Hauling

Harry Miller Excavating Co., Inc.
Box 54
Suffield, Ohio
Phone: Kent; OR 3-4111
Ditching

Missouri Valley Dredging Co.
1331 South 20th St.
Box 1592, Burlington Sta.
Omaha 8, Neb.
Phone: AT 0372
Joe G. McMaken, Pres.
Marine Dredging
Marine Construction
River Crossings

Modern X-Ray Co.
Box 152
Nevada, Mo.
Phone: Milo 11 or
Kansas City, DR 1-5323
Leonard O. Curry, Pres.
X-Ray Inspection

Monongahela & Ohio Dredging Co.
Ohio River & Lighthill St.
Pittsburgh 33, Pa.
Phone: ALlegheny 1-9500
R. E. Frankenberry, Pres.
Marine Dredging
Marine Construction

Lewie Montgomery Trucking Co.
Box 432
Odessa, Texas
Phone: FE 7-8647
Lewie Montgomery, Pres.
Iwana O. Montgomery, V. P.
Stringing, Hauling

Morain Coating & Const., Inc.
2719 Market St.
Youngstown, Ohio
C. F. Morain, Pres.
Coating & Wrapping

Muske Machinery Cartage, Inc.
Box 246
Franklin Grove, Ill.
Phone: 128
G. A. Muske, Pres.
Hauling

N

M. F. Nemlowill Welding Service
Box 82
Olmitz, Kansas
Phone: JUniper 6-2192
Welding

O

Oakley Engineering Co.
4849 West 21st St.
Tulsa, Okla.
Phone: DI 3-9208, LU 3-5311
F. H. Oakley, Pres.
Engineering Services

O. L. Olsen, Inc.
416 Pierce St.
Houston, Texas
Phone: FAirfax 3-9146
Station Construction
Engineering

P

Parkhill Truck Co.
1645 E. 21st St.
Box 3807
Tulsa, Okla.
Phone: RI 7-1351
Kenneth A. Owen, Pres.
Stringing and Hauling

Pentzien, Inc.
1504 Dodge St.
Omaha, Neb.
Phone: AT 9696
Louis I. Pentzien, Pres.
Marine Dredging
Marine Construction
River Crossings
Engineering Services

Permian Enterprises, Inc.
1004 Midland Natl. Bk.
Midland, Texas
J. H. Pittman, Jr., Partner
E. D. Kemper, Partner
Internal Cement Lining of Pipe

Petrol Structures, Inc.
30 Rockefeller Plaza
New York, N. Y.
Engineering

Pipelife Corp.
5903 Forest Park Rd.
Dallas, Texas
A. C. Curtis, Pres.
Internal, In-Place Cleaning, Coating
External Cleaning, Coating
Pigging, Retrieving Lost Pigs
Displacement of Fluids In Lines
Tank Cleaning, Coating

Pipe Line Service Corporation
3240 N. Mannheim Rd.
Franklin Park, Ill.
Phone: GLadstone 1-0600
F. C. Yeazel, Pres.
Coating and Wrapping

Pipeline Welding & Const. Co.
Box 189 College Rd.
Oswego, Kansas
R. S. Perkins, Pres.
Welding

Pipe Linings, Inc.
2414 E. 223rd St.
Box 457
Wilmington, Calif.
Phone: TErminal 5-8201
Robt. C. Sargent, Exec. V. P.
Internal, External Pipe Protection

Pipe Protection Service, Inc.
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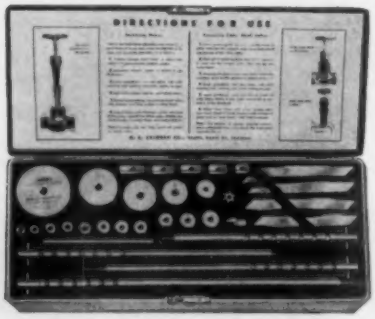

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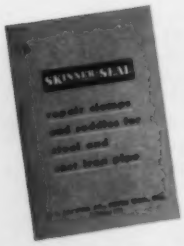

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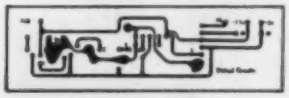

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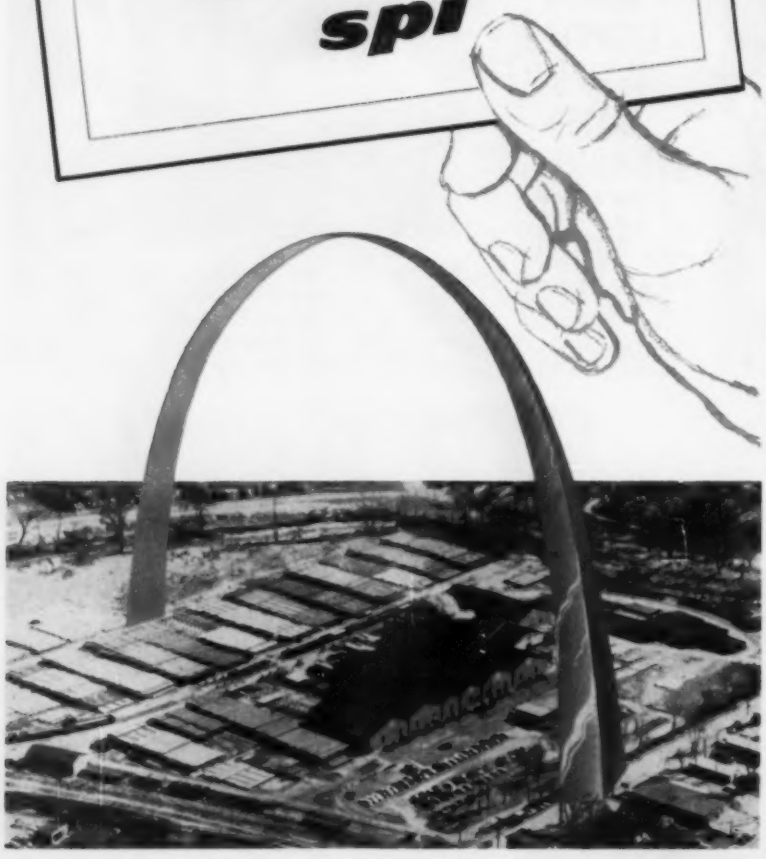

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Whatever your problem . . . designing a gathering system, or cross country trunk line, determining pumping horsepower, selecting welding equipment, planning a communications network, etc., . . . you will find basic data that will be of material help to you in the PIPELINE HANDBOOK ISSUE (February).

Underground Corrosion and Methods of Control

PART 2

O. C. Mudd, *Consulting Engineer, Alpine, Texas*

Decomposing vegetation or other organic matter result in organic acids that readily attack iron, hence, the exclusion of such material from the trench or backfill, particularly for uncoated pipe, reduces the chances of corrosion.

Organic decomposition rate is related to ground temperature (fermentation), thus the elimination of organic debris is more important in southern latitudes. In northern latitudes where ground water temperatures seldom exceed 50 F no noticeable corrosion from organic decomposition has been observed.

Corrosion from biochemical origin occurs when sulfate reducing bacteria infest soils adjacent to the pipe surface. The environment favorable to such bacterial development include the presence of sulfate chemicals, slightly alkaline soil, and organic materials, which serve as a food supply. They occur most frequently in soils where oxygen is excluded (anaerobic), however, species have been found to exist also in the presence of oxygen (aerobic).

Apparently in their life process sulfate chemicals are utilized in some way that results in the liberation of hydrogen sulfide. This nascent hydrogen sulfide readily attacks iron. Corrosion from this source is quite similar to that caused by sour crude oil (containing hydrogen sulfide) where conditions foster equivalent oxidation processes.

All types of corrosion involve electric current flow during the migration of metal from the anode surface to the electrolyte, and any unit of current flow during a unit of time, with 100 percent anode efficiency, results in the removal of the same amount of a specific metal, thus 1 amp flowing for one year removes 20.1 lb of iron. Anode surface barrier formations or metal composition (alloys) may lower anode efficiency. Graphite in cast-iron is an illustration of metal composition lowering anode efficiency.

Current flow in electrochemical cells cause potential differences between cell components and also cause potential gradients or drop along the path of flow through the connecting metallic circuit, between the cell electrodes and through the electrolyte. Current flow is measured in amperes or fractions thereof.

These potential differences, or drops, are measured in volts or fraction of a volt.

Resistance to current flow cause these voltage differences, or gradients, and this resistance in metallic conductors is determined in ohms (or fraction) per unit length, or suitable equivalent dimensional units, whereas the electrolyte resistance is usually determined as "resistivity," viz., the resistance between opposite faces of a unit electrolyte cube. The most common dimension unit is in centimeters, hence resistivity then is given as ohms per cubic centimeter or abbreviated as "ohms-cm^3."

INSTRUMENTS AND ACCESSORIES REQUIRED FOR CELL ANALYSIS

Instruments are necessary for the measurement of potential differences, current flow, and resistance to current flow, in the detection and analysis of corrosion cells. These instruments should be accurate, dependable, and constructed to survive field usage, and also weigh the least possible without sacrifice of desirable qualities.

Basic requirements include instruments to measure:

1. Potentials between a fraction of a millivolt (0.001 v) and 100 v. Indicating instruments are applicable for most observations, however, recording instruments are essential where fluctuating potentials are encountered. Recording instruments should include a weather-proof case, and when

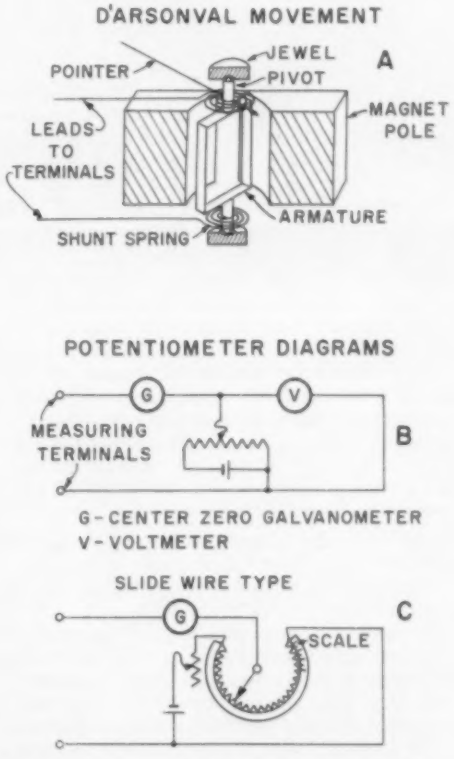

FIG. 5. Types of meters used in measuring d-c potentials.

more than one is required it is preferable to have all of equivalent sensitivity and scale adjustment.

2. Current between a milliampere (0.001 amp) and 100 amp. It is desirable to have at least one indicating instrument, however, by using suitable shunts, current can be accurately determined with a millivolt meter, either indicating or recording.

3. Soil resistivity measurements from a few ohms up to 200,000 ohms, or more, per cubic centimeter.

The most prevalent meters used in measuring d-c potentials, or current, are D'Arsonval type in which the armature (moving coil) carries the pointer extending to the calibrated scale. This armature is supported by pivots in jewel bearings and the pivots, or bearings, are easily damaged by shock and also subject to wear during use, particularly when abrasive dust gets to these bearings. Pivot, or jewel, damage impairs accuracy (Fig. 5a).

This type meter requires current flow through the armature to cause movement deflecting the pointer. The amount of this current flow, measured by d-c voltmeter, normally is indicated by the meter sensitivity given in ohms per volt. Thus a 1000-ohm-per-v instrument requires 1 milliampere to give full scale deflection and a 100,000-ohm-per-v instrument requires only 10 microamperes for a full scale deflection It is thus evident that the force causing armature displacement in a high resistance meter is usually less than with one of lower resistance, hence jewel or pivot damage may result in more serious errors with higher sensitivity instruments.

Because current to these meters flows through the test leads, the resistance of the leads have to be considered, especially when measuring in millivolts. A 1000-ohm-per-v meter indicating 10 millivolts full scale deflection has an internal resistance of only 10 ohms and long connecting leads may have resistance approaching that of the meter. If the connecting lead resistance equals that of the meter, then the indicated voltage will be only half the true voltage.

Potentiometer voltmeters eliminate errors from connecting lead resistance.

These potentiometers are of two basic types:

1. Where an indicating voltmeter is connected in a circuit, including a controlled voltage supply from a battery, and this controlled voltage is balanced through a galvanometer against the unknown voltage source connected by the test leads. Voltage balance occurs when the galvanometer indicates zero, thus current flow is also zero in the connecting leads. The accuracy of this type depends on the indicating voltmeters accuracy (Fig. 5b).

2. The second type incorporates a slide wire through which a controlled battery current flows, causing a voltage drop along this wire. Variations in voltage are obtained by sliding a contact along this wire, which is likewise balanced through a galvanometer against the unknown voltage. In commercial types the slide wire is formed on a circular or spiral support and this support includes the necessary scale arrangement to indicate the voltage reading when the galvanometer is balanced to zero. An included standard cell provides a means of instrument calibration at any time, thus assuring continued accuracy (Fig. 5c).

This last type is most rugged because the components are not easily damaged. These types usually include a galvanometer of the ribbon suspension type so constructed that shock damage is very remote.

Current measurements can be made by a suitable instrument (usually a D'Arsonval type) and some instruments include potential and current measuring facilities in one. With few exceptions a meter measuring more than a few milliamperes has shunts included within the instrument.

Suitable capacity shunts allow current measurements over a wide range with a millivolt meter or potentiometer and most commercial shunts are calibrated to give 50-mv drop across the instrument connecting terminals when the maximum rated current flows through the shunt.

A section of any conducting material, including pipe, may be calibrated for a shunt; however, such shunts may vary from calibration with temperature changes.

ACCESSORY EQUIPMENT

Connecting leads and electrolyte soil contacts with suitable accessory equipment are necessary in the segregation of cell components to determine their extent and nature.

Contacting a buried structure can be accomplished by providing a hole through the soil to the metal surface and then using a contacting probe having a hardened sharp point capable of penetrating into original metal. This form of contact may be expedient on uncoated thick-walled pipe, but it is to be avoided on coated pipe, especially thin-walled pipe. Prestressed steel used in much of the recent pipeline construction often operates near its strength limit and this stressed steel is more subject to failure by surface damage from sharp tools than unstressed metal.

Well-coated, and especially thin-walled, pipe should be provided with insulated test leads soldered, or welded, to the pipe metal and effective coating over any bare pipe or test lead metal to be buried.

Soil contacts are obtained by electrodes designed for the purpose and the type in most general use is the copper sulfate half-cell. This cell has a basic construction in which a saturate solution of copper sulfate contacts a copper surface connected to the electrode terminal and the saturate copper sulfate solution also seeps through a porous plug in one end, which normally is opposite the lead connection terminal. This seepage provides a means of contact with the soil surface to establish an electrolyte connection.

The Calomel half-cell, constructed similar to the copper sulfate half-cell, may be used also for the electrolyte contact.

Portable connecting leads are required in establishing a measuring circuit, which includes the measuring instrument. The length of these leads are dictated by requirements, but leads of any length must meet certain requirements to minimize measurement errors. The essential requirements are:

1. The conducting material to be of as low resistance as practical and of such construction as will allow repeated flexing without damage resulting in conductor resistance change.

2. Electrical insulation over the conductor to remain effective in excluding moisture from the conductor or allowing any detectable leakage from the conductor to exterior contacting materials of a conductive nature.

3. Any terminals attached to the ends of leads are secure enough to retain a constant resistance and also prevent electrolytic cell voltages at the junction of differing metals by moisture intrusion.

Test leads need periodic check of their resistance, particularly when subjected to hard use, because the fine strands become brittle from repeated flexing (cold working) resulting in strand breakage, and strand surfaces are frequently oxidized until the resistance between broken strands increase the lead resistance.

Unusual or erratic measurements noted when the lead contacts wet ground, or is submerged, gives evidence of insulation failure.

Meter variations when a lead is flexed at the terminal is indicative of poor terminal contact.

Clean terminal contacts are essential at all times if errors are to be minimized.

(To be continued in an early issue)

Three Lines Bring California Oil–Gas Ashore

FIRST DELIVERIES of natural gas from an offshore drilling platform in California waters are being taken by Pacific Lighting Gas Supply Company (Los Angeles), the gas transmission and storage subsidiary of Pacific Lighting Corporation.

Deliveries are averaging 1,000,000 cu ft of gas daily from production by Standard Oil Company of California and Humble Oil and Refining Company off a drilling platform set in 100 ft of water near Summerland, between Santa Barbara and Ventura.

Standard recently announced letting a contract for a second drilling platform to be located 1¾ miles away from the existing offshore site, in 106 ft of water.

Current deliveries may be made for a period of only 18 months should Standard and Humble decide they want to use gas for repressuring operations. If, on the other hand, pressure conrol is not indicated, deliveries would continue, on what Standard reports will be an increasing basis.

Gas to Absorption Plant

Pacific Lighting Gas Supply Company is taking the Standard-Humble gas at east Carpinteria, where Standard has completed an absorption plant. The gas comes to the plant site in one of three submarine lines laid on the ocean floor. Cost of the onshore facility was approximately $3,000,000. Standard reports facilities consist of two separators for treatment of black oil, two 5000-bbl tanks, through which the State of California meters the oil for its royalty purposes, one natural gas-fueled compressor, and a refrigeration system. Finally, the facilities consist of a crude tank 180 ft in diameter and 48 ft high for storage of oil, pending shipment by tanker to refineries.

Black oil and gas, produced from wells on the platform, will be separated on the platform for shipment to shore through the three pipelines, consisting of two 6-in. and one 8-in. pipe laid on the ocean bottom. The lines were buried 3 ft underground through the beach and surf zone to an offshore point where the water reaches 15 ft in depth.

Three Lines Laid

One 6-in. line will carry black oil to shore. The 8-in. line will carry gas produced from wells on the platform to shore. The second 6-in. line eventually will carry repressured gas back to the platform for gas lifting black oil from the wells. The 6-in. black oil line can handle 10,000 bbl per day of liquids.

Present production from the platform is about 1000 bbl of oil per day, along with the 1,000,000 cu ft of gas. Laying of the bundle of pipelines and the 20-in. submarine loading line were completed in about eight weeks by Morrison Knudsen Company, Inc., the prime contractor.

Pacific Lighting Gas Supply Company has built a metering facility at east Carpinteria, including a scrubber and an odorizer. The company is delivering the gas into the pipeline of its distributing affiliate, Southern Counties Gas Company.

Delivery from Standard-Humble, at 1000-psi pressure, is the highest ever taken by PLGS from a California producer.

PLGS has been taking some offshore production near Seal Beach and Rincon Point in the past few years. This, however, has been from wells drilled from man-made islands, rather than platforms. ★ ★ ★

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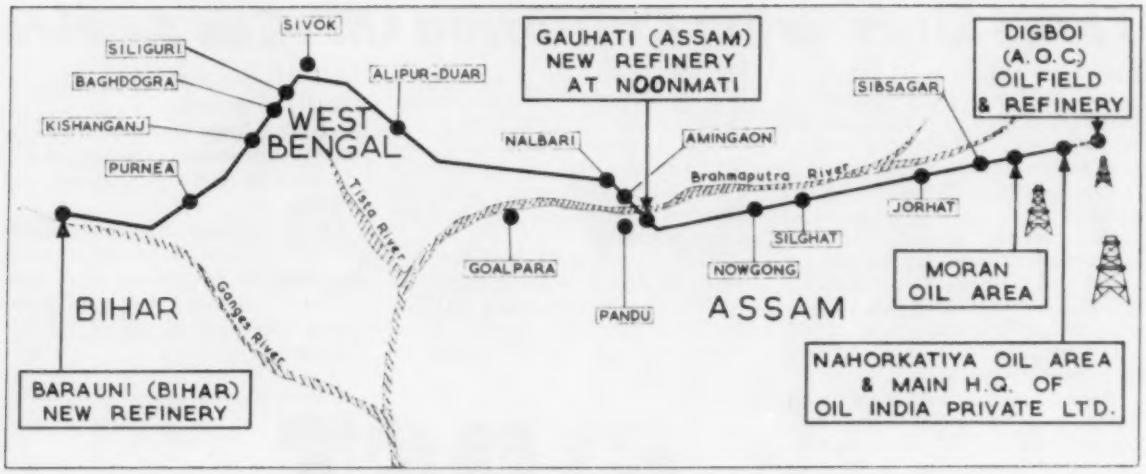


Route of Oil India Private, Ltd.'s crude oil line from Nahorkatiya producing area in Upper Assam to Gauhati.

Work Starts on Assam Oil Pipeline

India's longest crude line, 720 miles in length, will be constructed in two stages with completion by 1962

PIPE IS ARRIVING in Calcutta from steel mills in the United Kingdom, and work is getting underway on preliminary stages of the 720-mile Assam oil pipeline project for Oil India Private, Ltd., which will be India's longest pipeline.

First objective of the project is to connect Oil India's oilfields in Upper Assam by a 16-in. crude oil line to the site of a refinery to be built at Noonmati, near Gauhati, a distance of approximately 260 miles.

Second phase of the project will be the extension of the pipeline system, using 14-in. pipe, from a point near Gauhati to Barauni, in the State of Bihar, an additional 460 miles to the west, where a second refinery will be erected.

The job will be a race against time, weather, and the problems of transporting pipe and materials from Calcutta to upcountry areas in Assam, West Bengal and Bihar. The first stage of the pipeline has to be completed by the time the Noonmati refinery is ready to receive its first supplies of crude oil. The second link, to Barauni, should be completed by 1962, the date announced by the Government of India for the completion of the refinery there.

Oil India Private, Ltd., which will produce crude oil from its wells at Nahorkatiya and Moran in Assam and transport it to both refineries, have appointed The Burmah Oil Company (Pipe Lines) Ltd. as construction authorities for the project. Both refineries will be in the public realm of investment in India and will be operated by the newly-formed refining company, Indian Refineries, Ltd.

When the entire project is completed Oil India will deliver a maximum of 750,000 tons (5,250,000 bbl) of crude per annum to the Noonmati refinery and 2,000,000 tons (14,000,000 bbl) to the Barauni plant.

Fivefold Production Increase

Since mid-1953 when the Nahorkatiya oilfield was discovered by Assam Oil Company a total of 58 deep wells, most of them good oil producers, have been completed at Nahorkatiya, Hugrijan, and Moran. The current estimated potential of these areas is about 2,750,000 tons (19,250,000 bbl) per annum (more than five times the present volume of crude production in India) but further drilling and development operations are in progress in Assam and will continue throughout and beyond the period of pipeline construction.

Nahorkatiya, where since 1953 the greater number of wells have been drilled, will be Oil India's main headquarters and progress is being made with the provision of a power house, workshops, offices, and housing for the company's staff and workers.

Total investment by Oil India in the undertaking is 81 crores of rupees, of which the pipeline project will take 53 crores. As already announced, India has accepted credits of £23 million offered by The Burmah Oil Company, Ltd., and the British government toward the cost of building the pipeline system. The British government's share of the total (£3 million) will be spent on pipe and equipment manufactured in Britain.

Pipe deliveries for the first stage of construction, now arriving at Calcutta, will continue at the rate of 5000 tons per month until March 1960. Pipe for the second stage of the project will be supplied by Hindustan Steel, Ltd., whose plant at Rourkela, to be built by the West German firm of Mannesmann, is expected to be in operation in September 1960.

Route of Pipeline

Starting at Nahorkatiya, the route for the first stage of the pipeline generally follows the railway and roads on the south side of the Brahmaputra, passing through or near the towns of Moran, Nazira, Jorhat, Silghat, and Nowgong to Gauhati, all in the State of Assam.

In the second stage of construction the line crosses the Brahmaputra River from a point near Pandu to Amingaon and from there it will go by way of Nalbari (Assam), Alipur-Duar, Hasimara, Sivok, Siliguri, Bagdogra (all in West Bengal), Kishanganj and Purnea to Barauni, in the Monghyr District of the State of Bihar.

The terrain in Assam is largely paddy land intersected here and there by swamps, forest areas, and tea gardens, and, as much of the ground is often flooded for long periods in the rainy season, the job of laying the line, which will be buried for most of its length, will be possible only during the dry months of the year, from November to March.

Crossing the Brahmaputra

The Brahmaputra River crossing will be a major undertaking. Here the difficulties of fast-running flood waters, shifting pot holes in the river silt, whirlpools, and complicated approaches on both banks would call for employment of special equipment and techniques to lay a doubly-strong submarine pipeline beneath the river bed and out of reach of all dangers.

As an alternative, the pipeline could be suspended over the river. A third way, simpler and much less expensive than either of the plans, would be to accommodate the line on the new railroad bridge currently under construction across the Brahmaputra.

Besides the mighty Brahmaputra, eight other rivers, varying in width from 100 to 1000 ft depending on the season, are on the main pipeline route and will have to be crossed, and there are many smaller rivers and streams up to 100 ft in width. In all, there will be 78 river crossings.

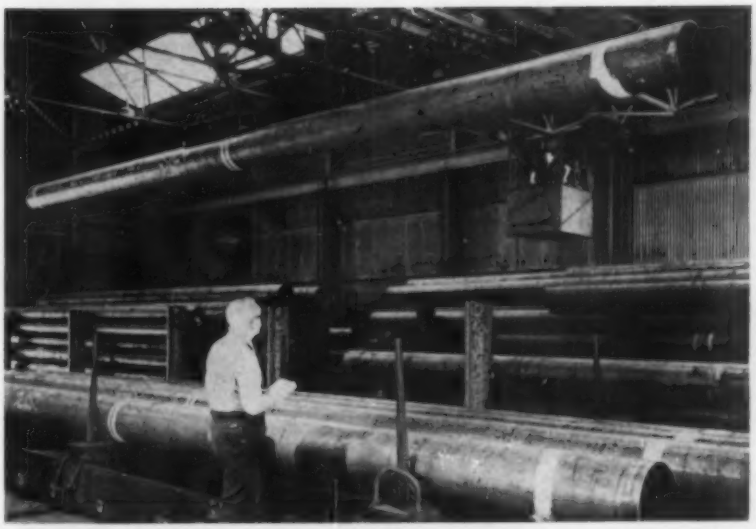
The pipeline either will be buried under the river bed, strung along existing rail or road bridges, or carried on cable suspensions. Some of the rivers to have submarine crossings are the Derai, Jhanzi, Bhogdai (Disai), Kakadanga, Kalang (Nowgong and Malankata), Hajo Suta (Sessanadi), Buradiya, Kujia, Tarang, and the Holong.

In the many irrigated areas a multitude of canals and ditches will present further obstacles to the construction program even during the dry season.

On its way from Upper Assam to Barauni the line will pass through many picturesque stretches of countryside in northeast India. In a sharp upward swing in the northern tip of West Bengal its route lies at the foot of the Himalayas not far from Darjeeling, one of the finest hill resorts in India. From the foothills near Sivok, in clear weather, the construction teams will see some of the highest mountain peaks in the world—the Kanchenjunga range, 28,146 ft high.

Right-of-Way

Much preliminary work will have to be undertaken before pipe laying can begin. In these initial stages, some of which are in progress, a detailed survey will be made of a 60-ft strip of land all the way from Nahorkatiya to Noonmati, and later to Barauni, for the pipeline system's legal right-of-way. Procurement and staking out of the land for this and for the several pumping stations will follow, and land also will be acquired for numerous up-country pipe stockpiles, material yards, and pumping station storage points.



Loading and checking 16-in. pipe at Stewart & Lloyds steel mill in Scotland. Pipe is being loaded onto railway cars by means of a crane-operated magnet.

While this work is in progress the supplies of pipe arriving in Calcutta for the first stage of the project will be shipped to various staging centers as close as possible to the pipeline right-of-way, and The Burmah Oil Company (Pipe Lines) Ltd. will operate a traffic control system at the port and other points to insure a smooth, speedy, and continuous flow of materials to the construction sites.

By this time the prime contractors for the pipeline construction job will have been named and order for all materials and equipment placed by construction authorities in accordance with tenders previously received. Several hundred tons of mobile equipment will be required — excavators, bulldozers, tractors, ditchers, boring machines, trucks and jeeps, welding machines, air compressors, barges, mud boats, coating and wrapping machines, and X-ray weld testing equipment — as well as pumps, valves, casing, etc.

Pumping Stations

Pumping stations, automatically operated, will be built at intervals along the line to push the crude oil along on its 2-mph journey to the proposed refineries. These stations will be connected to each other and to Oil India's pipeline operational headquarters at Gauhati and main headquarters at Nahorkatiya by VHF voice and teleprinter wireless. Maintenance stations, anti-corrosion stations, and mobile pipeline patrols also will be linked by the tele-communications network to the pumping stations and operational headquarters.

Waxy Crude

The characteristics of Assam crude oil, with its high wax content, and the crimatic conditions of the region traversed by the pipeline present an unusual pumping problem and for the past two years there have been experiments in the field and studies in laboratories in Assam and the U.K. to record its behavior in pumps, pipeline, storage tanks, and on the move. Exhaustive tests have proved that the crude is pumpable in a pipeline at any season of the year.

Close attention also has been given to public safety requirements of the system. The pipe will have extra-thick walls where it spans bridges and goes below rivers, and isolating valves will be installed on the line at intervals and at all vital crossings.

Longest in India

Although this will be the longest pipeline in India, during the war a "trunk" 6-in. line was laid from Bombay to Bhusawal and temporary oil lines were laid by military authorities from Calcutta and Chittagong to Assam and over the hills into north Burma and China, a distance of 1835 miles. The Bombay-Bhusawal trunk line was designed and built by engineers of The Burmah Oil Company who were also associated with the military pipelines in Assam.

Management of the new pipeline, when commissioned, will be in the hands of Oil India Private, Ltd. ★★

Pipeline Projects

Contracts Let On Tough Mexican River Crossings

Two construction companies face eight river crossings that will be some of the toughest in the world, according to pipeline experts.

They are Collins Construction Company and Constructora Inde S. A. de C. V. that will be involved in a joint venture to construct eight dual 24 and 12-in. water crossings on Petroleos Mexicanos' 291-mile, 24-in. gas pipeline, the longest ever attempted in Mexico.

The pipeline will connect Pemex City's new absorption plant in southern Mexico to industrial centers in the Valley of Mexico, near Mexico City. Feeder lines from the main line will also serve industrial centers along the way.

The rainy season from June to November is the third heaviest in the world, and during this time rivers are known to overflow their banks as much as 10 miles on either side.

One crossing, the Grijalva, is the seventh largest river system in the world.

From Pemex City, west to the foothills of the Sierra Madre del Sur, the crossings will be the Grijalva, Samaria, Tonala, Coatzacoalcos, San Juan, Tesechoacan, Obispo, and Papaloapan.

NGPL Seeks Lines To Benefit Chicago Area

Natural Gas Pipeline Company of America has announced a project now before the Federal Power Commission that would include construction of 151 miles of 36-in. pipeline and 180 miles of 24-in. line and increase peak day delivery capacity by 100,000,000 cu ft of gas.

The 36-in. line would be built in intermittent sections paralleling main line facilities between Ford County, Kansas, and Joliet, Illinois, while the 24-in. would be between existing facilities near Minneola, Kansas, and Kiowa County, Oklahoma.

The Peoples Gas Light and Coke Company subsidiary's new gas supplies would be apportioned among customer utility companies in the Chicago area, with Peoples Gas receiving approximately 40,000,000 cu ft.

Construction of additional metering and regulating facilities at Joliet, terminal point of the subsidiary pipeline, also would be required.

The new line would give NGPL access to areas containing proved and potential gas reserves believed to be of considerable magnitude. The gas supplies for this proposed expansion project have been secured under long-term contracts.

Transco Wins Ok With Con Ed Project Severed

Transcontinental Gas Pipe Line Corporation, while authorized to construct new pipeline facilities costing approximately $53,373,400, heard the Federal Power Commission defer any decision on the Transco proposal to build facilities to serve Consolidated Edison Company of New York, Inc.

The commission earlier denied this application, but an appeals court reversed that action and ordered the commission to restudy the case. In view of the court action, the FPC said, it decided the Con Edison proposal should be split off from the approved projects and considered later.

The approved construction constitutes about 129 miles of main line loops paralleling sections of the company's existing system in Texas, Louisiana, Alabama, Georgia, North Carolina, Virginia, Pennsylvania, and New Jersey, 53 miles of gas purchase laterals, and 59,280 hp in additional compressor capacity.

Peoples Gulf Files To Acquire TING Facilities

As the first step in a proposed realignment of Peoples Gas Light and Coke Company subsidiaries, Peoples Gulf Coast Natural Gas Pipeline Company and Texas Illinois Natural Gas Pipeline Company have filed a joint application seeking Federal Power Commission authorization for Peoples Gulf to acquire the facilities of Texas Illinois, which consist of 1225 miles of main line, 357 miles of lateral lines, 11 compressor stations with a combined capacity of 130,000 hp, and other appurtenant facilities.

Peoples Gulf is a newly-formed subsidiary wholly-owned by Peoples Gas Light and Coke, which also owns 70.56 percent of the outstanding common stock of TING and all of the stock of Natural Gas Pipeline Company of America.

Ultimately the interstate pipeline systems of NGPL and Peoples Gulf (TING) would be merged into one corporation.

New Michigan Crude Line

A 60-mile, 8-in. pipeline with an 18,000-bbl per day capacity is being constructed by Ohio Oil Company to assist in transporting crude oil from the Scipio, Pulaski, and Albion fields in Michigan.

The line will run from a point near Mosherville, Michigan, to Samaria, Michigan, at which point it will connect to another common carrier pipeline.

An additional 15 miles of 8 and 6-in. also will be laid from a point near Albion, southeasterly to connect to this main trunk line at Mosherville.

Tex Panhandle Gas Line

A 70-mile, 16-in. gas line from Ochiltree to McKee, in the Texas Panhandle, is planned by Shamrock Oil & Gas Corporation

Planned for completion by June 1, 1960, the line will move wet gas to a plant where liquids will be removed before sale of the residue gas to a pipeline.

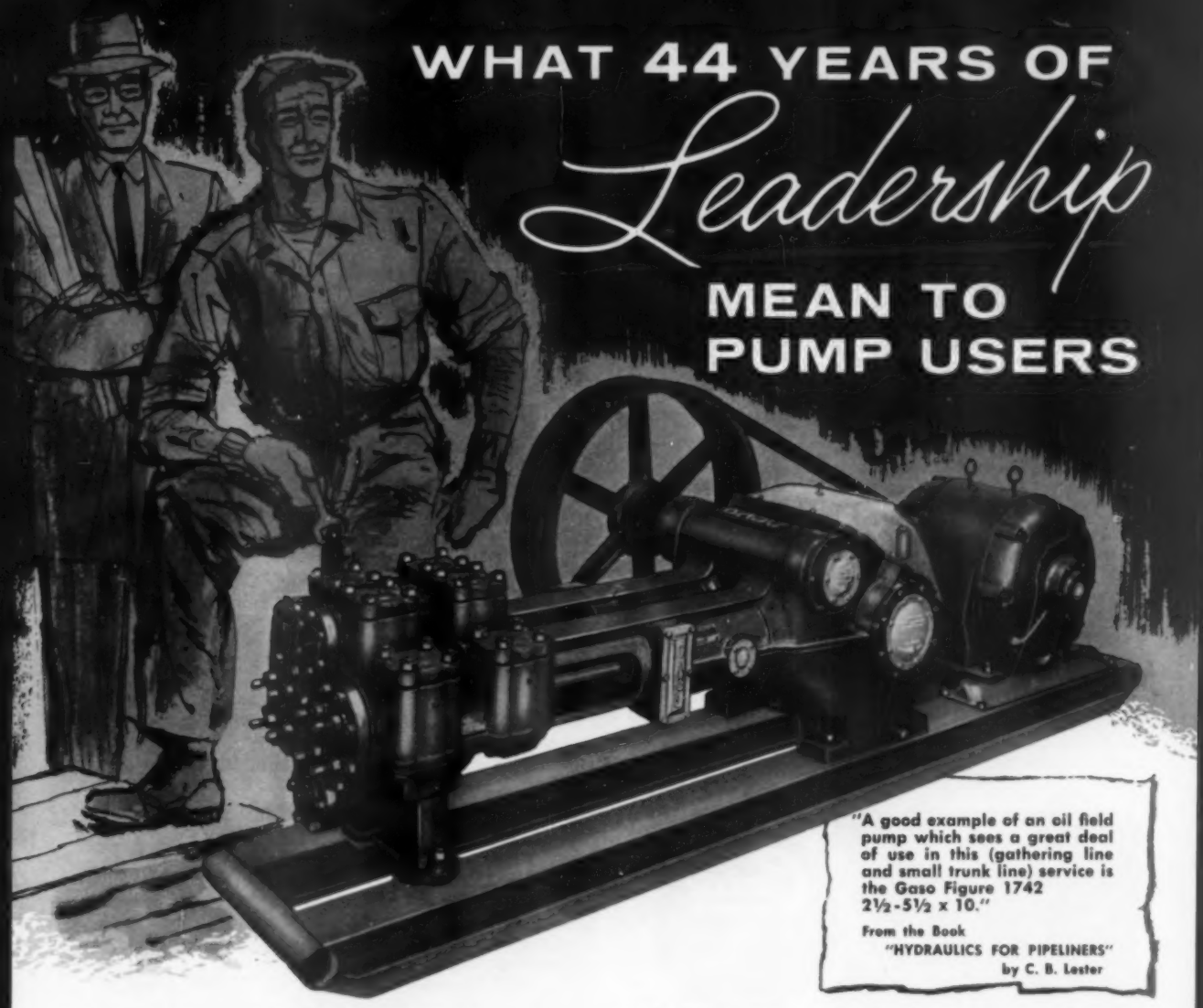
International Notes . . .

Britain's longest crude oil pipeline, extending 60 miles across South Wales linking BP's Angle Bay, Milford Haven, tanker terminal with the company's Llandarcy refinery near Swansea, has been completed. The 18-in., 100,000-bbl per day pipeline has been a year under construction and crosses nine major and minor rivers, 28 streams, 100 roads, and 12 rails.

In Syria, bid deadline is February 29, on a 310-mile, 6-in. products line to be built to Aleppo, Damascus, and Latakia from a new government refinery at Homs.

In Peru, bid deadline is January 15, on two pipeline projects totaling $3,000,000 under the expansion program of the Port Callao Authority, Apartado 255, Callao, Peru.

WHAT 44 YEARS OF *Leadership* MEAN TO PUMP USERS



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Examiner Oks Cimarron, Producers On NGPL Plan

Five natural gas producers and a newly organized gathering and pipeline company involved in Natural Gas Pipeline Company of America's efforts to secure gas from two Oklahoma fields have received a Federal Power Commission examiner's authorization.

The decision, subject to full FPC review, authorizes five independent producers to sell gas to Cimarron Transmission Company of Tulsa, Oklahoma, and Cimarron to sell the gas to Natural which would build 29 miles of 10-in. line costing $772,000. Cimarron would build a project estimated to cost $447,264.

Proved reserves in the two gas fields, Enville and Southwest Enville of Love County, Oklahoma, total about 90 billion cu ft. Based on a 20-year depletion, it was estimated that a daily average volume of 12,337,000 cu ft could be maintained for 17 years, with declining deliverabilities thereafter.

The decision conditions Cimarron's certificate to limit the rate of return and to modify the company's proposed depreciation of its project.

The producers are Pacific Coal and Oil Company, Texaco, Inc., Sinclair Oil & Gas Company, Shell Oil Company, and George E. Cameron, Inc.

Seeks Facilities in Texas

Seeking authorization to construct about 29 miles of 20-in. pipeline, a metering station, and a 2500-hp compressor unit in LaSalle County, Texas, Transcontinental Gas Pipe Line Corporation has filed an application with the Federal Power Commission.

The facilities, estimated to cost approximately $2,403,000, would be used to take natural gas from South Texas Natural Gas Gathering Company and initially would make approximately 360 billion cu ft of natural gas accessible to its pipeline system.

Seeks Compressor Facilities

Mississippi River Fuel Corporation, seeking authority to construct and operate 5000 compressor horsepower in the Woodlawn Field, Harrison County, Texas, has filed an application with the Federal Power Commission. Cost of the construction is estimated at about $1,374,350.

The company said that it has already installed seven field compressors totaling about 1650 hp. Additional units, aggregating about 3350 hp, would be installed when and as needed to overcome anticipated pressure declines in the field.

Get Budget Proposal Oks

The Federal Power Commission has approved budget-type proposals that will allow Panhandle Eastern Pipe Line Company and United Gas Pipe Line Company to construct from time to time facilities needed to take natural gas purchased from independent producers in the general area of their existing transmission systems.

Panhandle was limited to a total cost of $2,000,000, with single projects limited to $250,000. Panhandle's facilities would be constructed before August 1.

United's authorization to construct field facilities during the calendar year 1960 limited the total cost to $3,000,000, with the cost of any single project not to exceed $400,000.

"Temporary" On 18-In. Line

Temporary authority to construct and operate approximately 7 miles of 18-in. pipeline and a 2000-hp compressor station has been granted to Colorado Interstate Gas Company by the Federal Power Commission.

The $1,123,662 facilities will enable the company to take an average of 20,000,000 cu ft of gas per day in Hutchinson County, Texas, from J. M. Huber Corporation, which has already received FPC authorization to sell the gas to Colorado Interstate.

Canadian News Notes

Trans-Canada Sets 3-Year Looping Plan

A new three-year plan that would accelerate its western division main line looping and compressor station construction to start in 1960 instead of 1961 has been proposed by Trans-Canada Pipe Lines, Ltd.

The whole schedule, involving $161,784,446, is contingent on approval by the new National Energy Board of Trans-Canada's application to export 204,000,000 cu ft per day of gas from its main line at Winnipeg via Emerson, Manitoba, to Midwestern Gas Transmission Company in Minnesota.

The 1960 program, estimated to cost $45,730,065, calls for 74 miles of 34-in. main line loop, 51 miles of 30-in. lateral from Winnipeg to Emerson, 66,000 hp in new compressor capacity, as well as some local meter stations and the export sales meter stations. New 13,600-hp compressor stations will be built at Swift Current and Indian Head, Saskatchewan, and Portage la Prairie, Manitoba, while three existing prairie region stations will be enlarged by one 3400-hp unit each.

The largest looping program costing $69,323,807 is planned for 1961. It comprises 267 miles of 34-in. loop and another 52,000 hp in compressor capacity, including some increases in the northern Ontario sector and on the Toronto-Montreal section of the main line.

In 1962 the program involves only 122 miles of 34-in. loop and another 54,000 hp to compressor stations at a cost of $46,730,574.

The new construction will raise throughput capacities until by 1962 there will be rated capacity of 957,400,000 cu ft per day out of Burstall and 646,300,000 cu ft per day east from Winnipeg.

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

WITH THE PIPELINE CONTRACTORS

● **APV Company, Inc., 1801 Continental National Bank Building, Fort Worth, Texas.** Has been awarded contract to construct 61.4 miles of 30-in. from Pollock, Louisiana, to valve 63 for *Trunkline Gas Company*. Field office is in Pollock. A. Vaughn is superintendent, and W. L. Huff is spreadman.

● **Bechtel Corporation, 220 Bush Street, San Francisco 4, California.** Is double jointing for Engineers Limited Pipeline Company 79 miles of 26-in. pipe near Lafayette, Indiana. Fowler, Indiana, is the site of the first setup, and the second is at Pleasant Ridge, Indiana, with Arthur Rigby supervising both.

● **O. R. Burden Construction Corporation, P. O. Box 5216, Tulsa, Oklahoma.** Has underway 105 miles of 8 through 20-in. in Atascosa and Jim Hogg counties, Texas, for *South Texas Natural Gas Gathering Company*, with R. M. Jones supervising the job. Is constructing 75 miles of 6 through 8-in. line for *The Ohio Oil Company* between Albion and Samaria, Michigan, under the supervision of C. M. Hoffman.

● **Cape Construction Company, Box 423, Cape Girardeau, Missouri.** Has been awarded a contract by *Consumers Power Company* to construct 22 miles of 24-in. and 119 miles of 26-in. natural gas pipeline between White Pigeon and a point northwest of Detroit, Michigan. There are two spreads — one under Garland Mims, and the other supervised by Roy Whitworth.

● **Sam Carline, Inc., P. O. Box 138, Berwick, Louisiana.** Has been awarded contracts by *United Gas Pipe Line Company* for the laying of 9.5 miles of 16-in. pipeline south of Houma and 5.2 miles of 16-in. south of Morgan City, Louisiana, with field office for the former located at Houma under Jack Gibbs, superintendent, and field office for the latter at Berwick.

● **Collins Construction Company, P. O. Box 86, Port Lavaca, Texas.** Has in progress the construction of 20 miles of dual 32-in. lines for *Basrah Petroleum* from Fao, Iraq, to an offloading terminal in the Persian Gulf; and the construction of dual 12 and 24-in. natural gas pipeline river crossings for *Petroleos Mexicanos* between Pemex City and Mexico City in Mexico. For the latter, field office is in Minatitlan, Mexico, with Rug Stapleton as project manager.

● **Contracting & Material Company, 1235 Dodge Avenue, Evanston, Illinois.** Is laying 62.2 miles of 26 in. for *Trunkline Gas Company* from Tuscola to Rossville, Illinois. Two spreads will be used, under the general supervision of Jim McGill.

● **Engineers Limited Pipeline Company, 11858 San Pablo Avenue, El Cerrito, California.** Has been awarded a contract by *Trunkline Gas Company* to construct 136 miles of 26-in. pipeline from Rossville, Illinois, to the Indiana-Michigan border. H. H. Mehail will supervise the first spread at Fowler, Indiana, and Jake Cheeves will supervise the second spread at Goshen, Indiana.

● **R. H. Fulton & Company, P. O. Box 1526, Lubbock, Texas.** Has been awarded a joint contract with Houston Contracting Company and Western Pipe Line, Inc., to lay approximately 300 miles of 16, 12, and 10-in. trunk lateral lines in the Texas-Oklahoma Panhandle and West Texas-New Mexico area for *Transwestern Pipeline Company*.

● **Grayco Constructors, Inc., P. O. Box 4147, Austin, Texas.** Has contract with *Trunkline Gas Company* to lay a 53-mile, 30-in. line between Pitkin and Pollock, Louisiana.

● **Groninger & King, Inc., P. O. Box 1381, Pampa, Texas.** Is completing take-up of 76 miles of 2 to 16-in. line in the Shidler, Oklahoma, area for *Skelly Oil Company*. Frank Kelp is supervising at Shidler.

● **Hathaway Construction Company, P. O. Box 404, Carthage, Texas.** S. E. Hathaway is supervising a 3-mile, 3-in. tie-in between well and main line in the Carthage field for *Skelly Oil Company*.

● **Henuset Brothers, Ltd., P. O. Box 657, Virden, Manitoba, Canada.** Has been awarded a contract by *Saskatchewan Power Corporation* to construct 45 miles of 6-in. natural gas pipeline connecting the new casinghead-gas recovery plant of Imperial Oil, Ltd., in the Alida oil field with Saskatchewan Power's main transmission line in the Steelman oil field.

● **Houston Contracting Company, 2807 Buffalo Speedway, Houston 6, Texas.** Is constructing 17 miles of 12-in. and smaller lateral lines for *Gulf Oil Corporation* in the Puckett Field in Pecos County, Texas, under the supervision of Sam Downing at Fort Stockton, Texas. Has been awarded a contract by *Transwestern Pipeline Company* to lay the following: 149 miles of 30-in. from the vicinity of Corona, New Mexico, west to the vicinity of McCartys, with L. A. Young as superintendent in Corona; 55 miles of 30-in. and 89 miles of 24-in. from Corona, east to Roswell and southeast to Carlsbad, with M. L. Thompson as superintendent at Roswell; 61 miles of 20-in. and 76 miles of 24-in. from the vicinity of Fort Stockton, Texas, northwest to the vicinity of Carlsbad, New Mexico, with A. J. Slovack as superintendent at Fort Stockton; 166 miles of 24-in. from Roswell, northeast to the vicinity of Dawn, Texas; and a joint contract with R. H. Fulton & Company and Western Pipe Line, Inc., for approximately 300 miles of 16, 12, and 10-in. trunk lateral lines in the Texas-Oklahoma Panhandle and West Texas-New Mexico area.

● **C. S. LeNoir Construction Co., P. O. Box 798, Austin 64, Texas.** Is constructing 57 miles of 30-in. line for *Trunkline Gas Company* between Union City and Henning, Tennessee. W. B. Williams is superintendent. James Keene is spreadman, and R. E. McManus is office manager at the field office in Halls. Has received contracts from *Southern Natural Gas Company*, for 19 miles of 24-in. near Enterprise, Mississippi: and 43 miles of 20-in. between Wetumpka and Auburn, Alabama. C. H. LeNoir is spreadman and F. A. Phelps is office manager at Enterprise.

● **Macco Corporation, 14409 South Paramount Boulevard, Paramount, California.** Has prime contracts with various companies to construct pipelines in various sizes through 30-in. in California.

● **Majestic Contractors, Ltd., 408 Royal Trust Building, Edmonton, Alberta, Canada.** Has been awarded an undetermined amount of 4 through 10-in. crude oil gathering system to be constructed in the Estevan, Saskatchewan, area for *Producers Pipeline Company*. Jeff Minter is supervising at Estevan.

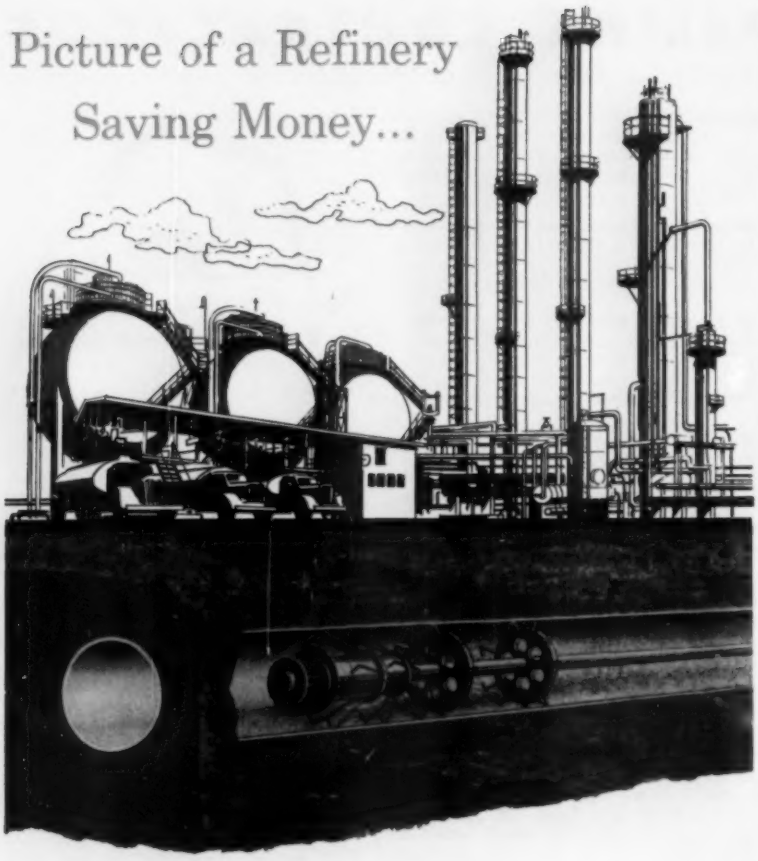
● **H. A. McGinnis Construction Co., North Dumas Avenue, Dumas, Texas.** Has been awarded contracts by *Phillips Petroleum Company* and *J. M. Huber Corporation* for an undetermined amount of 2 through 12-in. pipeline in Hutchinson County, Texas. Dumas, Texas, is the field office.

● **Panama, Inc., 2201 Commerce Building, Houston 2, Texas.** Is working two sections on the *Trunkline Gas Company* project. The first, with M. C. "Tex" Johnson as supervisor and Marks, Mississippi, as field office, starts approximately 15 miles northeast of Lambert, Mississippi, and proceeds in a southerly direction to approximately 6 miles northeast of Shaw, Mississippi. The second section, under the supervision of Eugene Coulter, is headquartered at Union City, Tennessee. The north end (approximately 30 miles) starts near Clinton, Kentucky, and proceeds south to a point near Union Ctiy, Tennessee. The south end (approximately 30 miles) starts about 9 miles southwest of Brownsville, Tennessee, and proceeds to a point near Oakland, Tennessee.

● **H. C. Price Company, Price Tower, Bartlesville, Oklahoma.** Has two spreads working on 335 miles of 30-in. pipeline across Arizona for *Transwestern Pipeline Company*. Spread One, supervised by G. A. "Abe" Reutzel, has commenced construction from Window Rock, Arizona, headquarters working west. Spread Two under the supervision of R. L. "Bob" Ezell begins at the California-Arizona border, working east. Headquarters for the latter spread have been established at Kingman, Arizona.

● **Sherman, Allen, Gay & Taylor, Inc., 3115 Buffalo Drive, Houston, Texas.** Has received a contract from *Pan American Argentina Oil Company* for construction of 107 miles of 6, 10, 12, and 14-in. crude lines from the Comodoro Rivadavia oil field in Argentina to the company's pipeline facilities on the Atlantic Coast. Dick Plake is field superintendent. Has been awarded a contract by *Trunkline Gas Company* to build 42 miles of 24-in. pipeline in Liberty and Hardin counties, Texas, with field office at Liberty under the supervision of E. D. Singleton.

Picture of a Refinery Saving Money...



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Contractors

● **Sheehan Pipe Line Construction Company, 514 National Bank of Tulsa Building, Tulsa, Oklahoma.** Has received a contract from *Transwestern Pipeline Company* to construct 300 miles of 4, 6, and 8-in. gathering lines in West Texas, Oklahoma, and New Mexico. Field office will be located at Higgins, Texas, under the supervision of J. W. Brown.

● **Steico, Inc., 905 Barton Springs Road, Austin, Texas.** Has been awarded a contract by *El Paso Natural Gas Company* to lay an undetermined amount of various size lines in the Shamrock field under the supervision of Al Blanchard and W. K. Hancock.

● **Turriff-Burden, Ltd., (subs. Burden International, Ltd., Box 5216, Tulsa, Oklahoma).** Has been awarded a contract by the *Iraq Petroleum Company, Ltd.*, for the construction of 315 miles of 30 and 32-in. pipeline from Kirkuk to the Syrian border and connecting Rumaila and Fao. The project office in London, England, will be managed by W. T. Barker. Field construction superintendent is John H. Miller; assistant superintendent is Arnold Smith; and manager of the field office in Baiji, Iraq, is G. E. Suagee.

● **Western Pipe Line, Inc., P. O. Box 1076, Austin, Texas.** Has been awarded a contract by *Transwestern Pipeline Company* to construct 100 miles of 10, 12, and 16-in. laterals in the West Texas-New Mexico area. Field office is in Monahans, Texas; Clint Schell is superintendent; and C. L. Siewert is general superintendent.

● **Williams Brothers Company, National Bank of Tulsa Bldg., Tulsa, Oklahoma.** Has been awarded a contract by *Northern Natural Gas Company* to lay 78 miles of 20-in., 11 miles of 16-in., 10 miles of 12-in., and 10 miles of 10-in. pipeline in Minnesota, as well as a St. Louis River crossing, with spread No. 1 headquarters designated at Pine City, Minnesota, under Don Foster, and spread No. 2 under Harlan Evens. Another contract with *Northern Natural Gas Company* calls for installation of 56 miles of 10 and 12-in. pipeline from Brainerd to St. Cloud, Minnesota.

NEXT MONTH...

Have you been assigned to design a communications system for your company?

PIPELINE HANDBOOK ISSUE will tell you the best type to select for your particular needs, how to estimate the cost, and similar information.

PIPELINE PERSONALS

E. J. Wacker, Jr.

E. J. Wacker, Jr., who was vice president of Magnolia Petroleum Company prior to its consolidation with Mobil Oil Company, has been named vice president of the recently expanded Magnolia Pipe Line Company. In addition to his executive responsibilities with Magnolia Pipe Line, Wacker will be concerned with engineering, electrical, research, and certain other activities.

J. D. Davis, assistant to the president of United Gas Corporation and formerly western division pipeline superintendent for United Gas Pipe Line Company, has been elected a vice president of United Gas Corporation.

D. J. Fuller, former management assistant with Imperial Pipe Line Company, Ltd., has been appointed operations manager of Producers Pipelines, Ltd.

Howard Keir has been named plant superintendent of Southern Counties Gas Company's general pipeline district, headquartered in Ventura, California, according to an announcement by **J. A. Millen,** vice president in charge of transmission and supply. Keir, formerly assistant plant superintendent at the gas company installation, replaces the late T. C. Wallace who died September 30.

William I. Ballentine, Jr., has been named chief engineer for the Southern Pipe Division of U. S. Industries, Inc., and will be responsible for research and development, inspection, industrial engineering, and plant engineering functions.

Max P. Watson, manager of gas purchases in United Gas Pipe Line Company's gas supply department, has been names assistant to **Ed Parkes,** president of United Gas Corporation and its wholly-owned subsidiaries, Union Producing Company and United Gas Pipe Line Company.

Donovan C. Wise has been named manager, operating plans and budget, for New York State Natural Gas Corporation. He will work closely with division superintendents and will assist the superintendent of operations in analyzing budget performance and recommending improvement programs. Wise also has served a sister firm, The Peoples Natural Gas Company, and has been chief compressor engineer at New York Natural's Oakford Station, Oakford district superintendent, and southern division superintendent.

John L. Kyser has been advanced from assistant manager to manager of Phillips Petroleum Company's supply and transportation department, the position held by **Harry G. Fair** until his election to vice president, supply and transportation, earlier this year.

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MODEL	TRENCH WIDTHS	MAX. DEPTH	DIGGING SPEEDS
130	12 to 24 in.	5¾ ft.	12 in. to 18 ft. per min.
150	16 to 26 in.	5¾ ft.	12 in. to 25 ft. per min.
170	20 to 32 in.	5¾ ft.	12 in. to 25 ft. per min.
420	36 to 52 in.	7½ ft.	15 in. to 25 ft. per min.
520	40 to 52 in.	8½ ft.	12 in. to 28 ft. per min.

Also: 5 ladder-types for digging 6 INCHES to 6 FEET wide . . . up to 19 FEET deep

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Personals

J. F. Nolan

James F. Nolan, superintendent of the Ohio Fuel Gas Company's right-of-way department, has been elected to a three-year term as a national director of the American Right of Way Association and will represent Ohio at national meetings of the ARWA. Currently concluding a two-year term as secretary of the organization, Nolan also has served as its treasurer.

R. M. Pemberton, assistant superintendent in Olney, Illinois, for Pure Transportation Company, has been transferred to Gueydan, Louisiana, as superintendent.

James C. Dotson, former district superintendent at Lovington, New Mexico, for Service Pipe Line Company, has been transferred to Casper, Wyoming, to supervise operations of lines that run from the Elk Basin, Pilot Butte, Beaver Creek, Sussex, and Salt Creek fields into the Casper area, then on east to Fort Laramie. Dotson also will supervise the system from Fort Laramie south to the Wyoming state line and the line from the Wyoming state line east to Scottsbluff, Nebraska. He replaces former district superintendent **John H. Keyes, Jr.,** who has been assigned to Baytown, Texas, as manager of the 300-mile Bayou Pipe Line products system. Service recently purchased the interest of American Oil Pipe Line Company in Bayou and has been designated to become the operator this month.

Edgar U. Cochrane, formerly director of industrial relations of Tennessee Gas Transmission Company, has been promoted to vice president of Tennessee Gas Pipeline Company, the division which operates the firm's pipeline system and gas transmission business. **Claude Lilly,** formerly Tennessee Gas personnel manager, was promoted to its director of industrial relations, succeeding Cochrane.

A. W. Peabody, well known as a lecturer on corrosion control and writer of numerous articles on the subject, has been appointed supervising engineer of the corrosion engineering group of Ebasco Services Incorporated. He has been with the company 22 years.

R. B. (Bob) Hastie has been named assistant regional superintendent of Atlantic Pipe Line Company's West Texas-New Mexico region, filling the vacancy created when **R. G. (Dick) Dulaney** was named regional superintendent. Hastie is formerly administrative assistant in the company's Southwestern division.

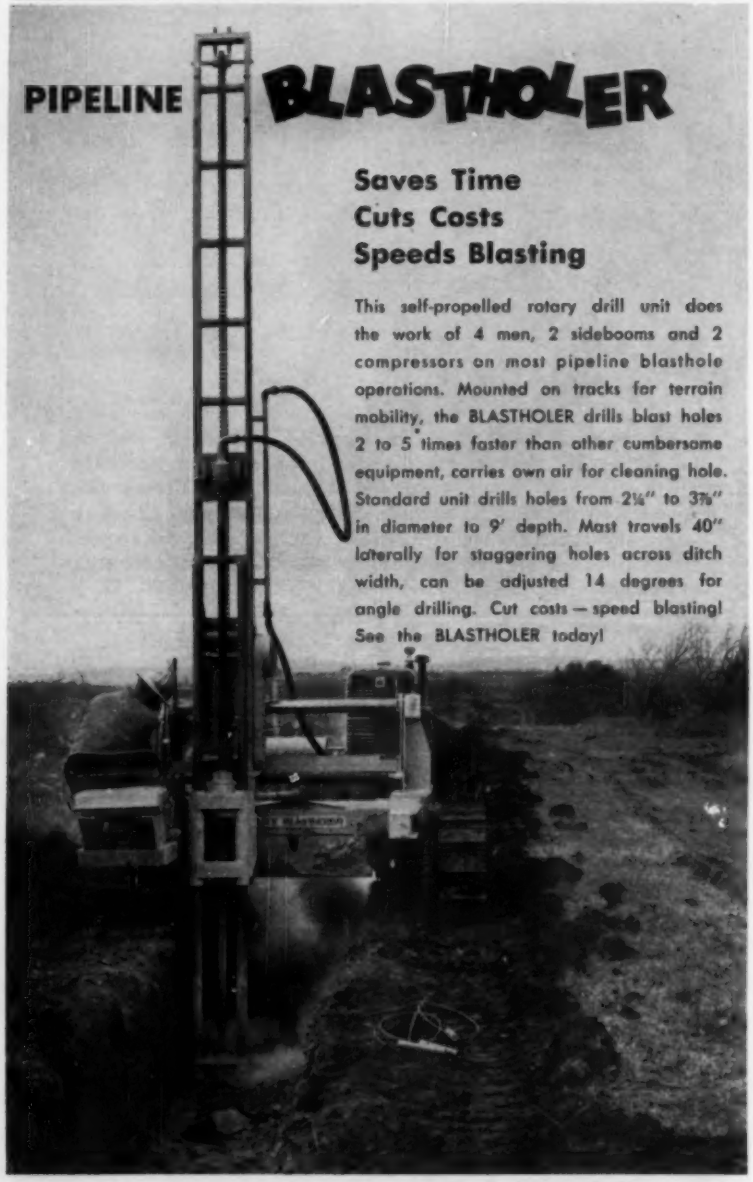
Russell W. Wetjen, who has served on the board of directors of the Pennsylvania Liquefied Petroleum Gas Association and is a former member of the National Affairs Committee of the national LPGA, has been named vice president and general manager of American Meter Company's recently-acquired subsidiary, the Granberg Corporation.

Harry K. Phipps, manager of Mobil Pipe Line Company's central division at Wichita, Kansas, was named Kansas oil man of the year at the oil centennial celebration. The Wichita Oil Secretaries Association sponsored the event.

John W. Brand, recently moved to Tulsa, Oklahoma, to become a vice president of M. J. Crose Manufacturing Company, has now been named vice president and general manager of the soon-to-be-merged Crose and Perrault Equipment Company which will carry the new corporate name of Crose-Perrault Equipment Corporation. Brand will retain active management of Crose-Curran, Ltd., in Canada, in addition to his new duties at Tulsa. All of the key personnel of Perrault have been retained, along with Crose's men, to make up the organization of the newly merged companies, **Clare G. Miller,** president, announces. In addition, **John Behrenfeld,** a vice president, has been transferred to New York City to head the export department; **Ben Montgomery** is a newly elected vice president in charge of the company's Houston division; and **W. H. "Buck" Royal** has been appointed sales manager, the post formerly held by Behrenfeld, and has been moved to Tulsa from Denver where he was manager of the western division of Crose.

W. A. Tabb, veteran of more than 32 years of continuous service in compressor station operations of United Gas Pipe Line Company and predecessor companies, has retired. He has held the position of chief engineer at three locations, most recently at Edna in the Houston, Texas, district.

Talmage Reese, communications and corrosion man at Panola in the Shreveport district of United Gas Pipe Line Company, has retired. Reese is a veteran of over 32 years with United Gas Pipe Line and predecessor companies.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Saves Time
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This self-propelled rotary drill unit does the work of 4 men, 2 sidebooms and 2 compressors on most pipeline blasthole operations. Mounted on tracks for terrain mobility, the BLASTHOLER drills blast holes 2 to 5 times faster than other cumbersome equipment, carries own air for cleaning hole. Standard unit drills holes from 2¼" to 3⅞" in diameter to 9' depth. Mast travels 40" laterally for staggering holes across ditch width, can be adjusted 14 degrees for angle drilling. Cut costs — speed blasting! See the BLASTHOLER today!

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It's New | Pipeline Equipment

Electronic Detector

A new electronic detection instrument is the "Signalmaster," Model TR-1A, that locates and traces pipes, cables, and conduits to a depth of 18 ft; measures the

depth of a line, and pinpoints valves, caps, risers, junction boxes, etc. The unit is completely transistorized, lightweight, and requires only small flashlight batteries for power. *The Goldak Co.*

Circle number (81) on reply card.

New Tractor, Matched Equipment, Transmission

Simultaneously with the introduction of new power shift transmissions that provide Caterpillar D8 and D9 tractors with instantaneous, one-lever control of gear shifting without interruption of power and momentum, the manufacturer has announced a new Series D9 that incorporates a higher-output turbocharger and undercarriage improvements. The new unit is available in a choice of direct drive or torque converter drive, as well as the power shift version, with hydraulically-controlled bulldozers. Heart of the new power-tailoring arrangement is a planetary gear set, driven integrally by the engine flywheel, which transmits ⅓ of the engine torque directly to the transmission input shaft, and the remaining engine torque through the torque converter. *Caterpillar Tractor Co.*

Circle number (82) on reply card.

Valve Operator, Lubricator

Roto Hammer is a self-contained mechanical operator, free of pneumatic or electrical power, designed to not overlubricate valves but to allow additional lubrication if desired by the operator. It provides a ground level control for remote operation of overhead plug valves, enables valves in overhead lines to be installed in straight runs and makes possible hand operation of such overhead valves at ground level. The unit is also offered as a hand operator for valves at ground level. *Roto Hammer Company.*

Circle number (83) on reply card.

Louder Radio Messages

A new, fully transistorized 15-w speaker for use with Motorola's MOTRAC two-way radio line triples normal speaker audio output enabling users to hear radio messages even when hundreds of feet from their vehicles or in noisy locations. An 8-ft coil cord and special mounting brackets provide temporary mounting of the "Power Voice" speaker on the outside of the vehicle window. *Motorola Inc.*

Circle number (84) on reply card.

New 40-Ton Crawler Crane

A new 40-ton, 1¼-yd crane, mounted on a 14 ft by 13 ft crawler and handling up to 110-ft of boom, features the manufacturer's "Shear-Ball" connection — which eliminates adjustment, maintenance, and lubrication problems — and the manufacturer's patented square-tubular-chord boom. Boom-tip extensions may be added up to 40 ft. Air power controls are another feature. A torque converter multiplies engine torque automatically as digging conditions require. The rear counterweight is easily detached for weight reduction in highway transport. The new crawler crane is convertible to dragline, clamshell, crane, or hoe. *The Thew Shovel Company.*

Circle number (85) on reply card.

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For obtaining more accurate gas sampling, this proven Arcco-Anubis instrument is unexcelled. It replaces older, inadequate methods for spot sampling. This sampler will over a period of seven days accumulate at a constant rate a sample of gas to a final pressure at or near 130 psig from a sample source, the minimum pressure of which is not less than 150 psig.
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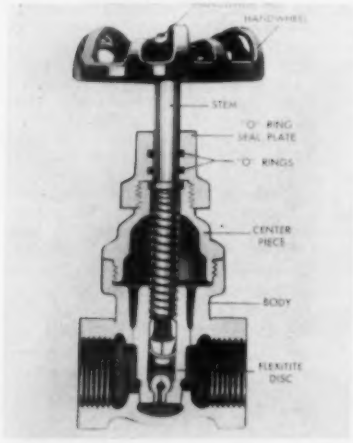
New Equipment

"O" Ring Gate Valve



A new brass gate valve features two "O" rings in place of ordinary fiber asbestos packing. The "O" rings are placed in an "O" ring seal plate — the top "O" ring serving as a dirt seal, and the bottom one serving as a fluid seal. The slotted flexitite disc has a slight flexibility which automatically compensates for small misalignment of seat faces to assure a leak-tight contact over the entire seat surface. The Musco "O" ring gate valve is designed for general service on lines where straight through flow is desired and for complete shut off on steam, water, natural gas, air, oil, and vacuum systems. *Modern Utility Supply Co., Inc.*

Circle number (86) on reply card.

Smaller Power Inverter

Changes, including size reduction, have been announced for the Onan "Instapac," a transistorized inverter power unit for microwave communication emergencies. The unit is now available in 19-in. relay rack mounting, with necessary controls, or wall mount cabinet; in three input voltages — 24 v, 36 v, and 48 v; and with optional battery charger, meters, and output booster. Although only in 1 kva sizes, it can be used in combinations for applications requiring greater capacity. It can take over critical loads instantly and operate essential equipment until a generating plant can take over, or it may be used as a sole source of standby power. *D. W. Onan & Sons, Inc.*

Circle number (87) on reply card.

Rotary Air Compressor Features HP Increase

A newly designed 125 cu ft per min rotary portable air compressor features increased horsepower capacity; automatically regulated engine speed to meet air demand; anti-blowback suction unloading valves; a larger, tamper-proof, weatherproof toolbox; automatic water circulating system that insures that compressor and engine operate at a constant temperature, despite temperature changes; and finger-tip-hydro shift clutch that disengages the compressor to protect it from "dry starts" in cold weather. Under normal conditions the clutch serves as a flexible coupling and safety feature between compressor and engine, and it is not necessary to disengage it. *Gardner-Denver Company.*

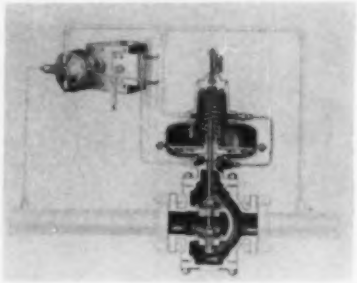
Circle number (88) on reply card.

Digs to 30 Ft per Min

Full production of a 1 to 30 ft-per-min tandem drive trencher is announced. The completely mobile trencher—mounted on rubber-tired wheels—provides road speeds up to 30 mph and features point-of-balance shifter which allows a 24-in. shift forward or back—comparable to shifting 1500 lb in either direction, allowing the machine to perform such feats as crossing trenches without backfilling. It has a hydraulically-operated four-speed digging wheel, controls within inches of the steering wheel, and three conveyor belt speeds for placement of spoil banks. *Speicher Brothers.*

Circle number (89) on reply card.

Remote Pressure Control



A remote control drive unit that will set remotely most Fisher Governor Company pilot operated gas regulators has been announced for use in gas pipelining where great distances and widely varying local conditions present many problems in properly controlling pressures. The Series 606 "Kixcel" is an electric power source that turns the pilot's adjusting screw either for an increase or decrease in the reduced pressure of a system. It is controlled from a remote station by means of conventional telemetering equipment or by a d-c control signal supplied from a polarized signal transmitter. *Fisher Governor Company.*

Circle number (90) on reply card.

Easy-to-Install Coupling

Flexmaster is a compact, streamlined, corrosion resistant pipe coupling consisting of seven components that assemble to form a lightweight, reuseable unit suitable for all types of hot water lines, lube oil systems, and air lines in a variety of industries including industrial stationary engines and process piping systems. Only two nuts and bolts on the hinged coupling ends allow ease and speed of assembly. The Flexmaster allows up to 5-deg angular misalignment when joining pipe and permits both angular and axial pipe movement without leakage. Pipe vibration and shock are absorbed by the gasket. *Marman Div., Aeroquip Corporation.*

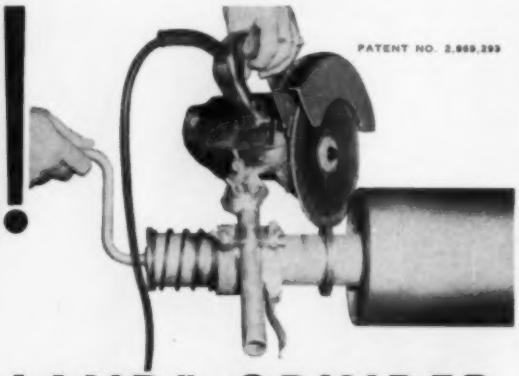
Circle number (91) on reply card.

Timer Has 2 Timing Heads

A new pneumatic time-delay relay is now available for applications where two separate timers would normally be used for on-delay and off-delay operation. Two timing heads operate from a common magnet assembly to provide time delay after energization and de-energization. Each timing head has a single-pole double-throw snap switch with an adjustable timing range of 0.2 sec to 1 min. *Square D Company.*

Circle number (92) on reply card.

NEW! H&M



"BEVEL-LAND" GRINDER

automatically cleans and lands pipe bevels

The new H & M "BEVEL-LAND" GRINDER employs an electric grinder to automatically clean and smooth pipe cuts and put the land on bevels. The machine may be placed on the pipe and in operation in less than one minute. A simple adjustment in angle of the grinding wheel is all that is required to change the machine from the cleaning to the land position. The H & M "BEVEL-LAND" GRINDER assures more postive alignment of pipe and better quality welds. The machine is available in two models: one for 6" to 14" and one for 14" to 36" pipe.

WRITE FOR YOUR COPY OF A CATALOG SHEET WHICH DESCRIBES ALL THE FEATURES OF THE NEW H & M "BEVEL-LAND" GRINDER.

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New Tape Handlers

Three new continuous-loop transports are being made available for handling magnetic tape lengths up to 35, 80, and 100 ft and in width to 2 in. Designed for detailed analysis programs, such as those in conjunction with analog computers and with wave analyzers to examine the full frequency spectrum recorded over varying reel time periods, the loop mechanisms have isolated tape path under the multitrack record and playback heads for high precision, low-flutter performance. The Series 3190 transport has up to nine tape speeds. *Minneapolis-Honeywell Regulator Co.*

Circle number (93) on reply card.

New Off-Highway Trucks

A new series of off-highway heavy-duty trucks offers a choice of gasoline, LPG, or diesel powered engines, six basic models in both four-wheel and six-wheel design, and gross vehicle weight ratings ranging from 46,000 to 73,000 lb. Design features include diamond plate steel fenders, heavy-duty brush guard, double-channel heat-treated frame, two new rear axles, and a broad selection of heavy-duty optional components. New rear axle on the standard four-wheel model is rated at 35,000 lb. A new tandem rear axle, rated at 44,000 lb, is offered on the six-wheel. *International Harvester Co.*

Circle number (94) on reply card.

Compact Computer Has Large-System Features

Particularly adaptable to oil pipeline transmission problems is the new, small, transistorized, stored-program IBM 1620 data processing system that can perform more than 100,000 calculations a minute. It requires little more space than the average desk and can perform computations on a continuous or production basis. It includes 20,000 digits of magnetic core storage with variable field length and immediate accessibility, and paper tape and electric typewriter input and output. The availability of two advanced programming systems and a comprehensive library of mathematical and statistical routines simplifies programming. Specific programs for the petroleum industry will be available. Conventional decimal arithmetic is used, providing ease of communication between man and machine. *Data Processing Div., International Business Machines Corp.*

Circle number (95) on reply card.

All-Aluminum, Outdoor Switchgear Housing

To provide an answer to outdoor switchgear housing corrosion problems, Allis-Chalmers has introduced the Aluma-Clad switchgear housing for A-C switchgear. It features an open-labyrinth cross-section of panels, developed in conjunction with the Reynolds Metals Company, that snap together to form walls, floor, and roof, permitting an increased flow of air through filters in the bottom and out of the top of the housing. Major sections are joined by aluminum alloy bolts with closed-cell neoprene gasketing between adjacent panel sections. *Allis-Chalmers Mfg. Co.*

Circle number (96) on reply card.

Antenna Protection

The Para-Dome is a new, inexpensive parabolic reflector and antenna protective cover molded of glass fiber reinforced resin and available for 4, 6, 8, and 10-ft diam antennas. The glass fiber cone withstands windloading of 50 lb per sq ft. There is no signal attenuation through the 10,000 mc range. A simple, high strength, cast aluminum clamp assembly is of a unique non-skid design with teeth that lock the Para-Dome to the antenna, eliminating slippage under maximum wind conditions. Added protection to the antenna is afforded by an extension flange on the glass fiber cover. A joint engineering project of *Redman Pattern Works* and *Tower Construction Company.*

Circle number (97) on reply card.

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EXPERIENCE MAKES THE DIFFERENCE

...and a world of experience in testing thousands of miles of pipelines makes the difference in every Williams testing job.

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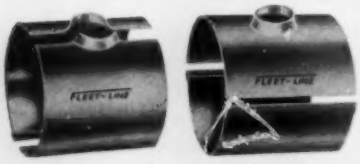
SADDLES: Conventional, and for pressure vessel heads. Nozzle sizes from ¼" to 24". Fleet-Line saddles weld neatly into place in much less time, and with much less welding rod.

Full encirclement saddles.



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It's New | Pipeline Literature

New Tractor Gear Shift

A step by step explanation of how the new SynchroTouch Transmission Control operates is given in new 8-page booklets on the 345 hp Caterpillar DW20 and DW21 Series G tractors. Schematic drawings illustrate the sequence of events involved in "shifting" by dialing the desired gear. *Caterpillar Tractor Co.*

Circle number (98) on reply card.

Two-Way Radio Line

A new bulletin on G-E's Transistorized Progress Line two-way radio equipment describes how small size (8½ in. wide, 12 in. long, and 4 in. high) makes possible a wide variety of positions in which the equipment may be mounted in cars and trucks. Charts are included showing how the car's battery can be saved due to the low power required by the new TPL unit which uses only 0.04 amp on "standby." *General Electric Co., Communication Products Dept.*

Circle number (99) on reply card.

Heating Coils Data

A new heating coils bulletin contains explanations, graphs, charts, and illustrations for standard steam, hot water, steam distributing, and double distributing coils. Included are construction and dimension data, air friction charts, temperature rise charts for pressures ranging from 2 to 30 lb steam, condensate rates, water velocity and pressure drop graphs, heat transfer factor graphs, M.T.D. chart, net weights for different lengths and coil sizes, architectural specifications for different types of coils, coil design formulae, and piping diagrams. *American Air Filter Co., Inc.*

Circle number (100) on reply card.

Compact Planetary Gears

Space and weight-saving gears for speed reduction or speed increasing service on high-horsepower transmission applications are described in a new 8-page bulletin. Cutaway drawings, construction details, capacity and selection curves, and tables of dimensions are included on eight sizes of De Laval-Stoeckicht planetary and star gears for pump drives, compressor and blower drives, and turbine and internal-combustion engine drives. *De Laval Steam Turbine Co.*

Circle number (101) on reply card.

Hydraulic Reference Manual

An hydraulic reference manual, with a special section devoted exclusively to hydraulic equipment and other sections dealing with construction, diesel, and other fields, has been published. Items illustrated and described with engineering specifications, technical drawings, and suggested usages include hydraulic motors and pumps, hydraulic control valves, hydraulic cylinders, and a-c and d-c generating plants. *Groban Supply Company.*

Circle number (102) on reply card.

Electric Plant Catalog

A new line of high-capacity electric generating plants—ranging up to 170,000 w (gasoline) and 230,000 w (diesel)—and basic models of Onan gasoline and diesel engine-driven generator sets are contained in a new catalog. A chart of representative models within each specific series outlines such details as capacity of the plant, voltage, starting method, dimensions, and weight. *D. W. Onan & Sons Inc.*

Circle number (103) on reply card.

Wall Chart On Piping

Useful for installation and maintenance personnel and individuals requisitioning valves of all types is a 17-in. by 22-in., 3-color wall chart, "Recommended Piping Practice." It is fully illustrated and divided into sections on basic valve types, connections normally used, installation and maintenance tools, installation and operation and maintenance. *Lunkenheimer Co.*

Circle number (104) on reply card.

Vibration Meter Data

Covered in a new bulletin are the specifications and applications of the SIE Model T-1A battery-powered vibration meter that has been designed for measurement of velocity, displacement amplitude, and acceleration of vibration. *Southwestern Industrial Electronics Co., Div. of Dresser Industries, Inc.*

Circle number (105) on reply card.

Three-Cylinder Power Units

Three-cylinder closed and open diesel and gasoline power units manufactured by Hercules are featured in two new bulletins, one describing the overhead-valve units that operate on either gasoline or natural gas and develop up to 48.5 hp at 2200 rpm, and the other describing the direct-injection diesel units that develop up to 46 hp at 2000 rpm. *Hercules Motors Corporation.*

Circle number (106) on reply card.

Conservation Tanks

An approach to vapor loss problems in tank storage is set forth in the new booklet, "Wiggins Conservation Structures." The manufacturer describes its: Hidek floating roof, designed so that any type of main drain may be used without danger of accumulating product on top side and with large outer and center pontoons and adjoining deck for easy access and inspection; its Lodek floating roof, particularly adapted to storing corrosive crudes; its double deck roof providing greater slope for drainage; and other structures, as well as: the Wiggins Safety Seal, providing a mechanical closure to stop evaporation losses in welded or riveted tanks and accommodating 10-in. variation of annular space between roof and shell; and the EverSeal, a resilient circumferential solid cushion seal between the sides of the tank and the pontoons of the floating roof. *General American Transportation Corp.*

Circle number (107) on reply card.

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

New Literature

Industrial Controls

A new industrial controls catalog presents a comprehensive line of General Controls products including: automatic temperature, pressure, level and flow controls; counters; switches and automation controls; industrial actuators; combustion instrument controls; controller and pressure indicators the Hammel-Hahl Division and Foster Engineering Division lines, as well as relays, transformers, and time switches; and a special section on "Hydramotors," electro-hydraulic actuators having many patterns, designs, and valve body materials. *General Controls Co.*

Circle number (108) on reply card.

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Operation and construction features of the 6500-lb capacity, 4-wheel drive, rear-wheel steer W-10 Terraload'r tractor shovel are described in a new 16-page, 3-color, illustrated catalog. *J. I. Case Co.*

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- **Quantities required to coat pipe?**
- **How to size and select orifice meters?**
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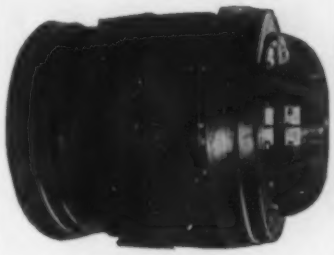

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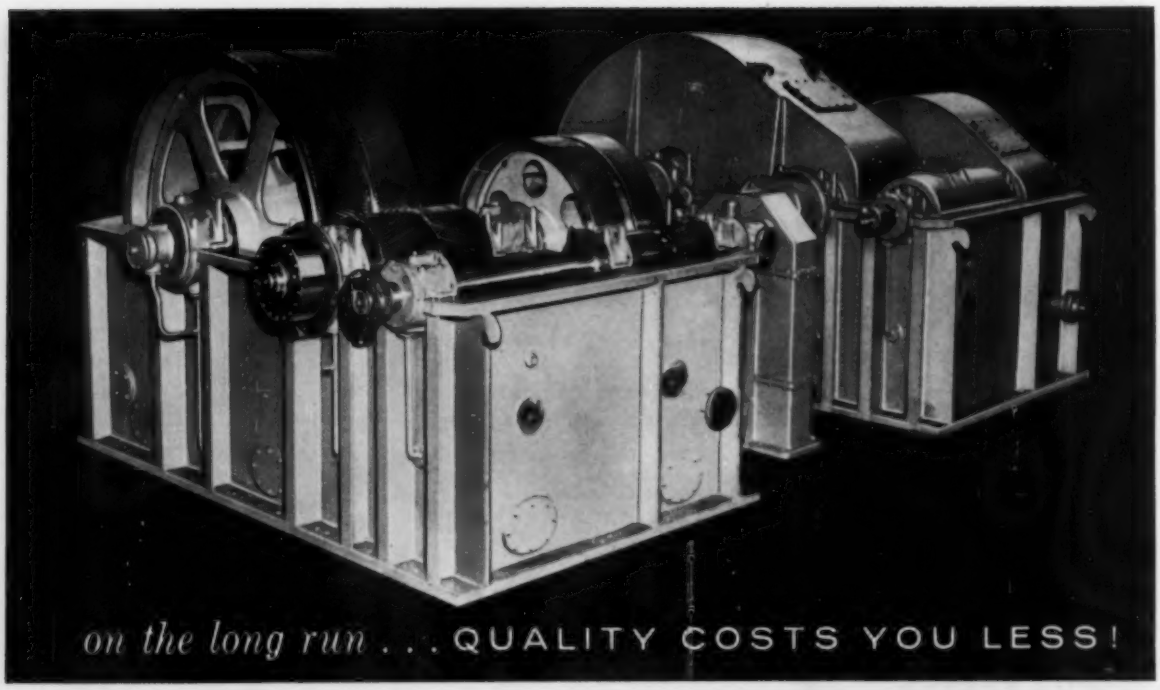

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EFFICIENCY — Western Gear high precision manufacture guarantees low power losses through the gear drive ... a vitally important factor in the high proven efficiency of engine driven pipeline centrifugal compressors. Certified factory full-load, full-speed tests show a maximum of 2.0% loss through the 5,000 horsepower 2-stage drives pictured. Truly exceptional, considering the unit size and relatively high speeds encountered ... over 6,000 r.p.m. and 15,000 f.p.m. pitch line velocity.

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WG

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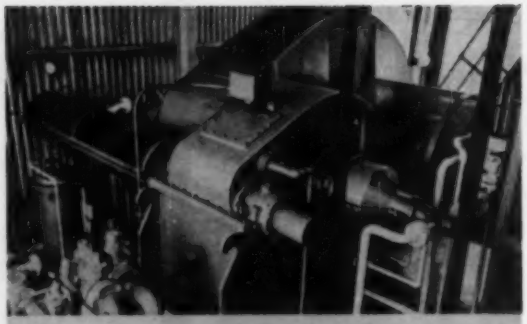

Photo above shows one of twenty units installed over three years ago on Columbia-Gulf Pipeline (formerly Gulf-Interstate Pipeline). Units are of the 2-stage type similar to the ten units currently being supplied for Transwestern. Cooper-Bessemer natural gas engines capable of delivering 5,000 horsepower at 360 r.p.m. drive through Western Gear Corporation Model 4525THS20-16 pipeline drives to Cooper-Bessemer centrifugal compressors at 6,050 r.p.m.

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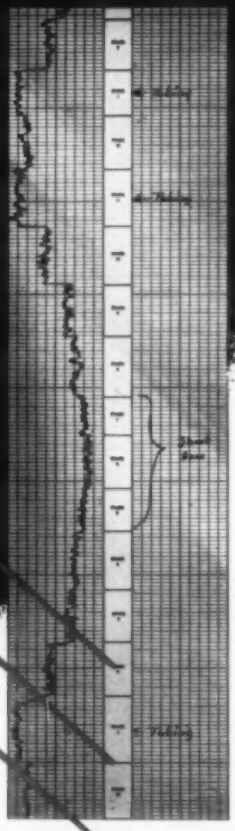

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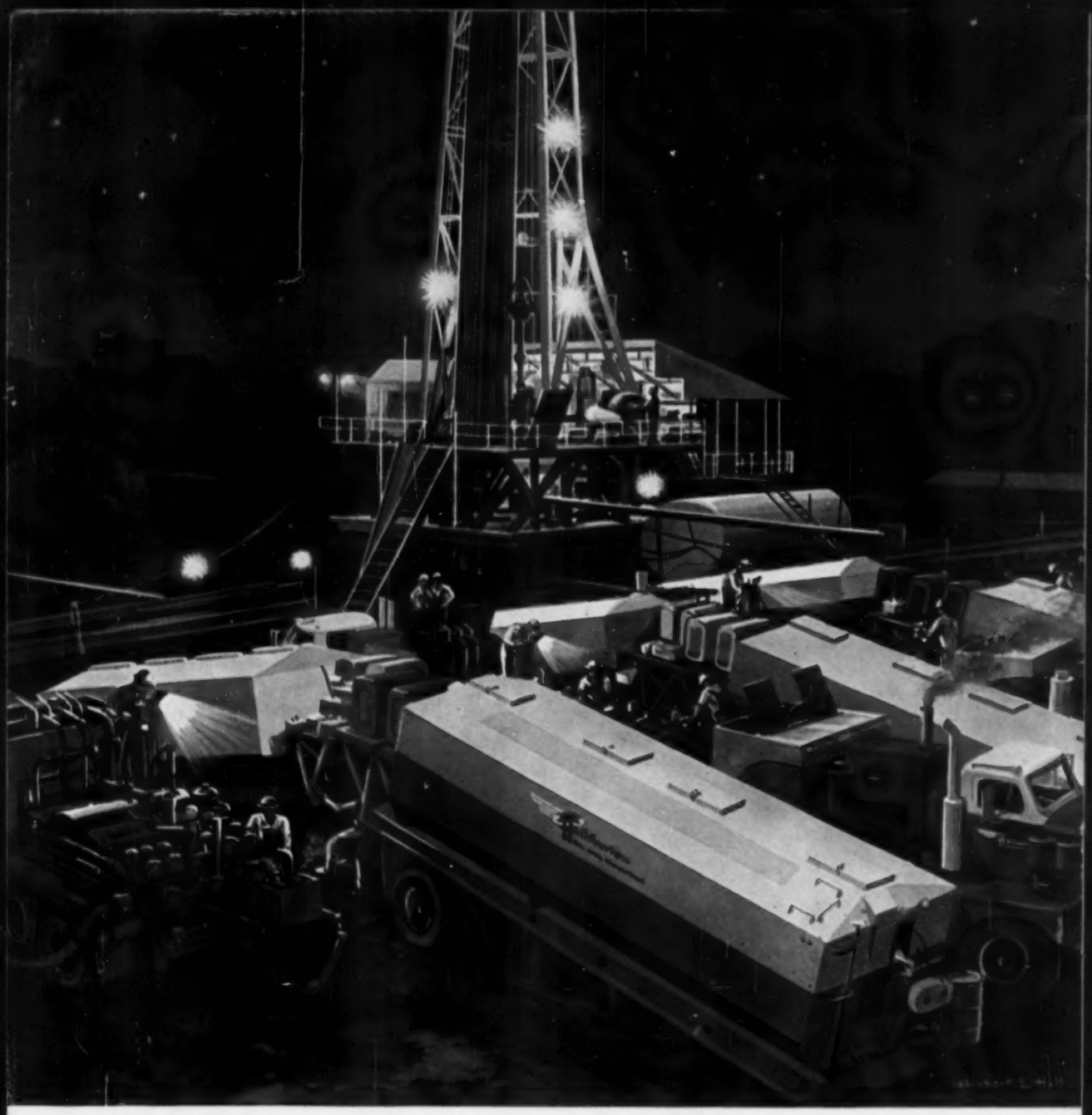

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